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Ohe et al.

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(45) **Date of Patent: *Jan. 25, 2005**

(54) OPTICAL TRANSMITTER-RECEIVER MODULE, METHOD OF MANUFACTURING THE MODULE, AND ELECTRONIC DEVICE USING THE MODULE

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(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 39 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/305,096**

(22) Filed: **Nov. 27, 2002**

(65) **Prior Publication Data**

US 2003/0113072 A1 Jun. 19, 2003

(30) **Foreign Application Priority Data**

Nov. 30, 2001 (JP) 2001-367135

(51) **Int. Cl.**^{7} **G02B 6/42**; G02B 6/36
(52) **U.S. Cl.** **385/88**; 385/24
(58) **Field of Search** 385/88, 89, 92, 385/93, 59, 76, 78, 43; 398/135, 138, 139, 163; 359/152, 163

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Primary Examiner—Frank G. Font
Assistant Examiner—James P. Hughes
(74) *Attorney, Agent, or Firm*—Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

In an optical transmitter-receiver module for performing optical transmission and reception by using a single-core optical fiber, a light-tight partition plate unit **506** for separation between an optical path of a transmission signal light and an optical path of a reception signal light is held between a jack section **508** for detachably holding an optical plug **240** and a light emitting/receiving unit **505** having an LED **514** and a PD **515** positioned and fixed in place and molded in one piece.

10 Claims, 27 Drawing Sheets

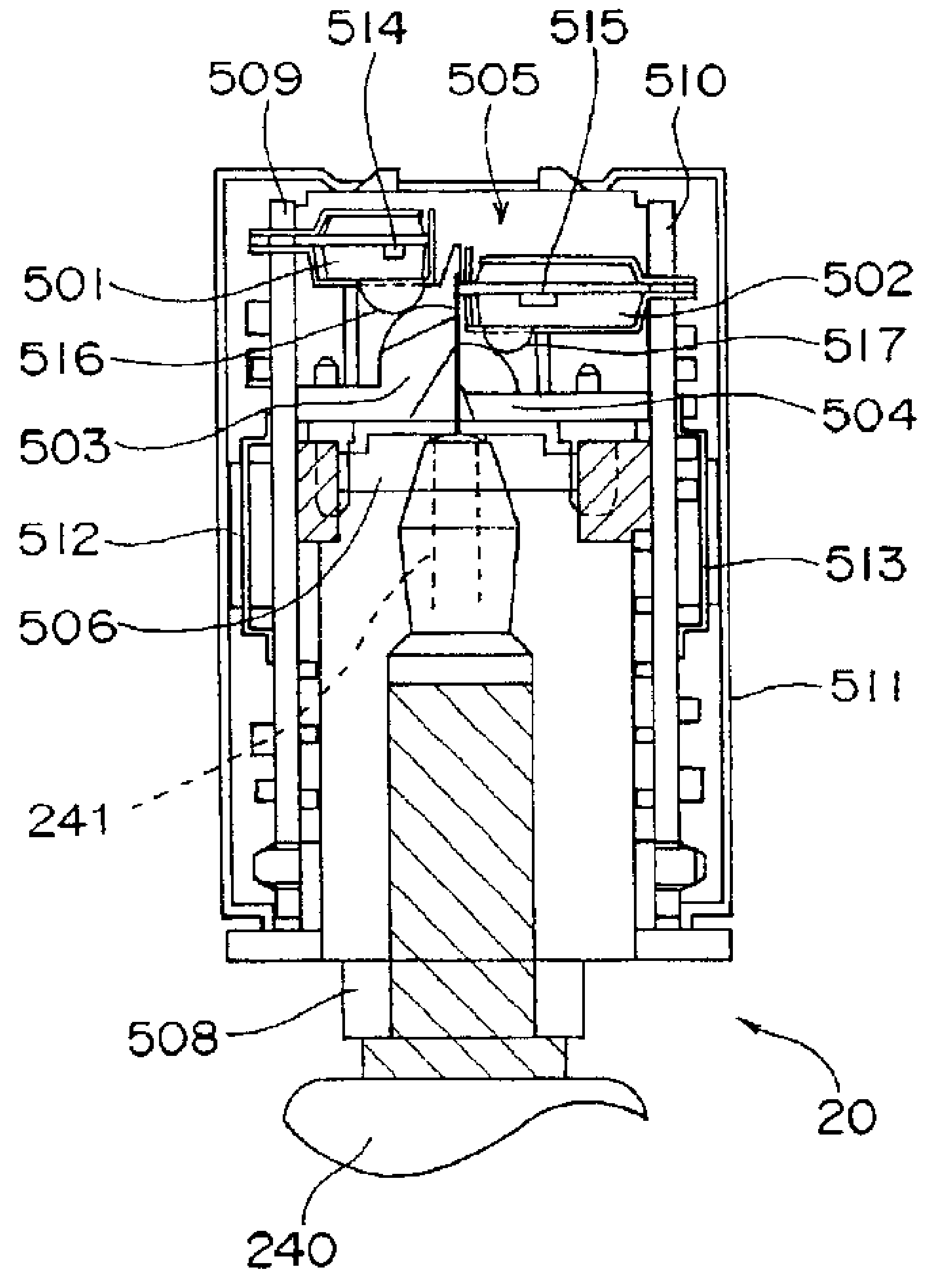
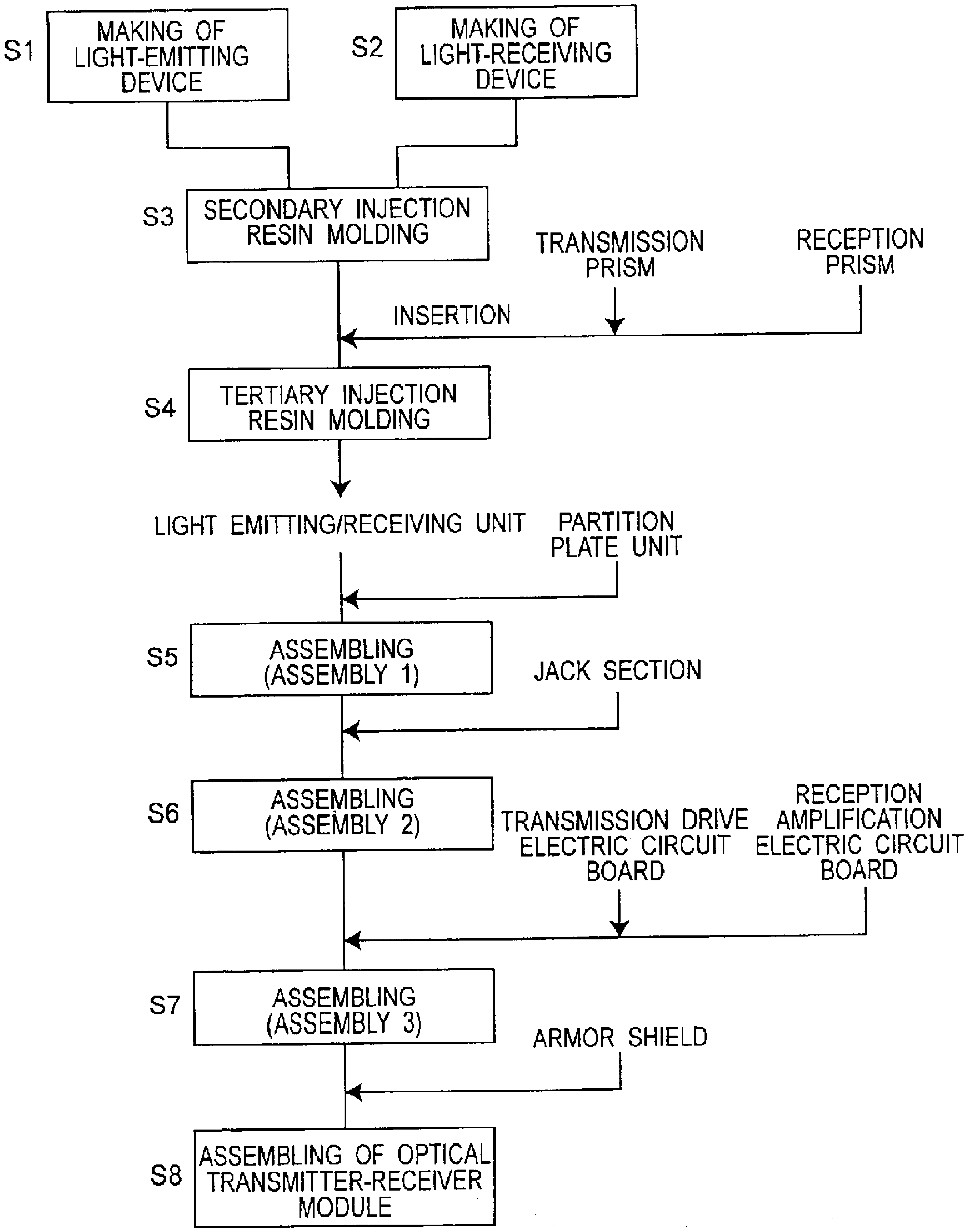


Fig. 1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MAKING OF LIGHT-EMITTING DEVICE
S2
MAKING OF LIGHT-RECEIVING DEVICE
S3
SECONDARY INJECTION RESIN MOLDING
TRANSMISSION PRISM
RECEPTION PRISM
INSERTION
S4
TERTIARY INJECTION RESIN MOLDING
LIGHT EMITTING/RECEIVING UNIT
PARTITION PLATE UNIT
S5
ASSEMBLING (ASSEMBLY 1)
JACK SECTION
S6
ASSEMBLING (ASSEMBLY 2)
TRANSMISSION DRIVE ELECTRIC CIRCUIT BOARD
RECEPTION AMPLIFICATION ELECTRIC CIRCUIT BOARD
S7
ASSEMBLING (ASSEMBLY 3)
ARMOR SHIELD
S8
ASSEMBLING OF OPTICAL TRANSMITTER-RECEIVER MODULE

Fig.2

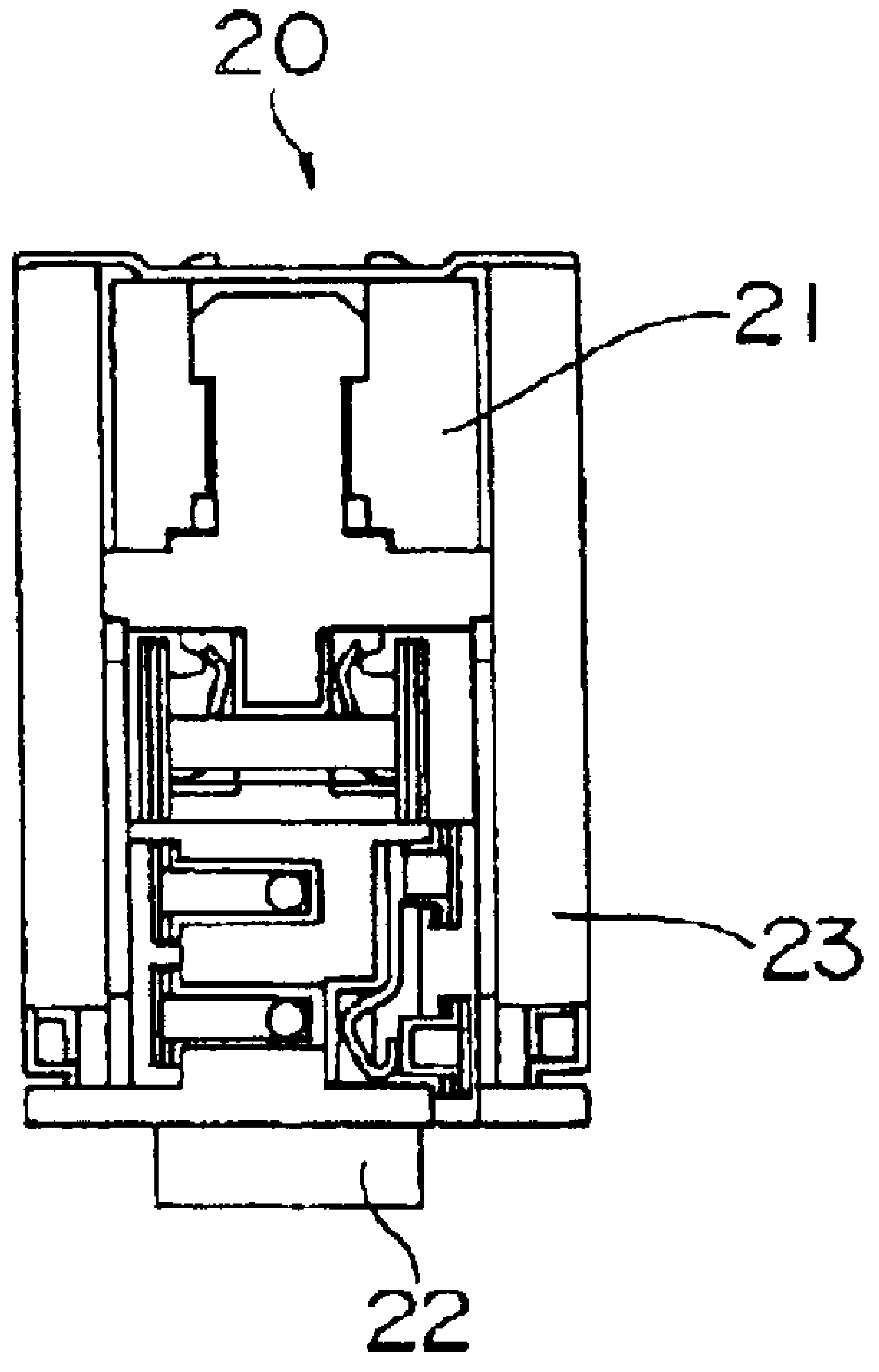

Fig.3

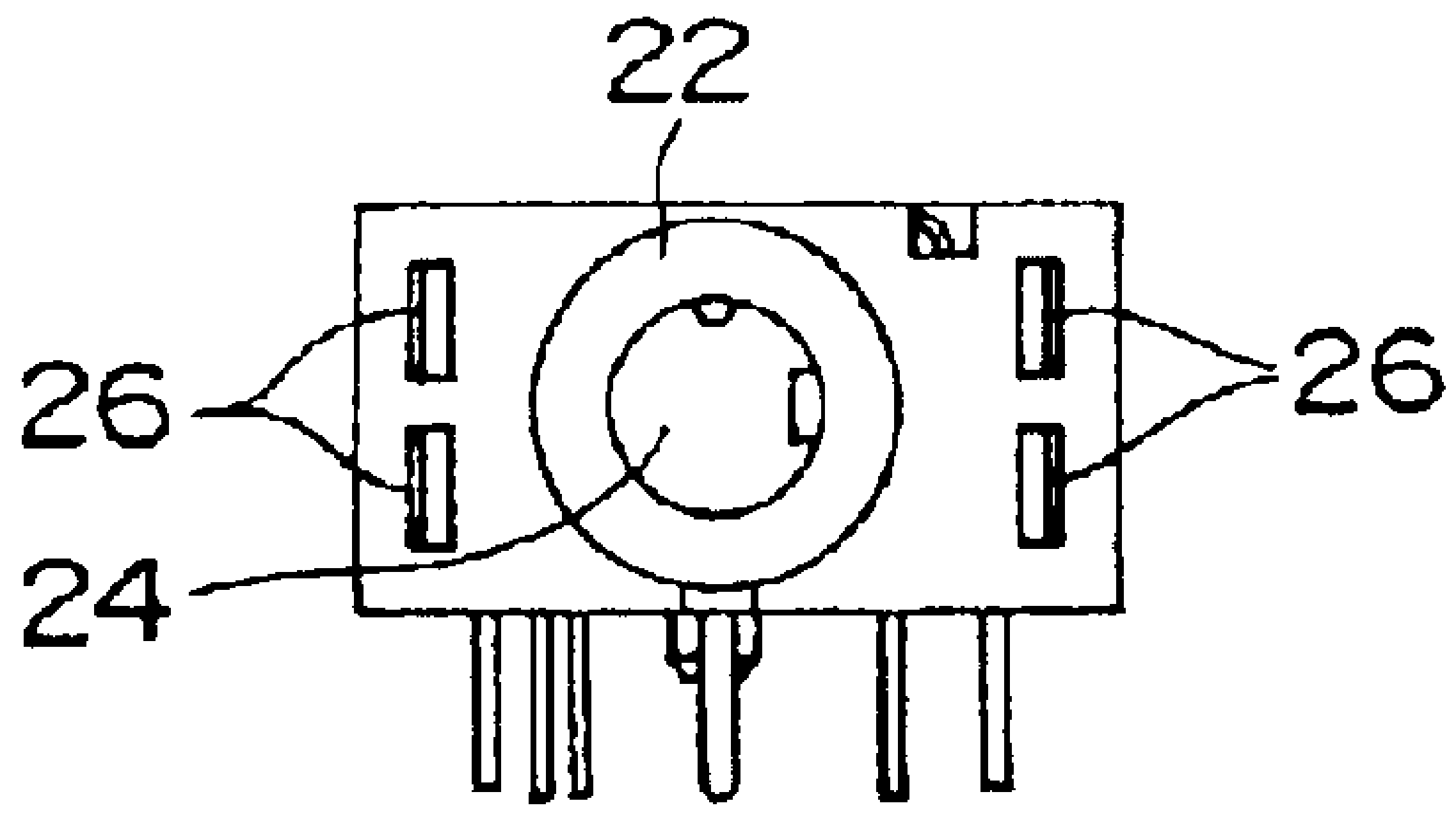

Fig.4

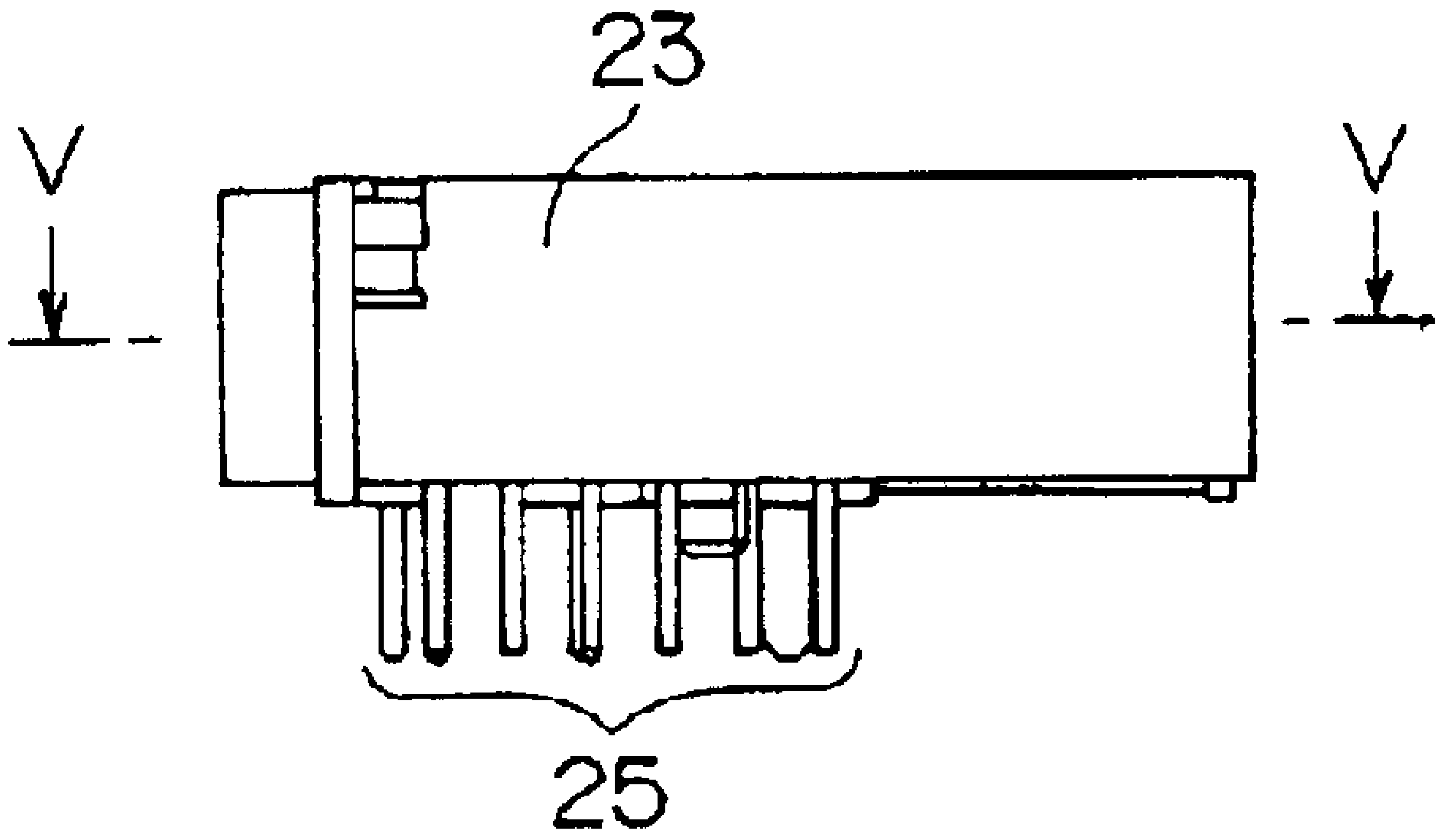

Fig.5

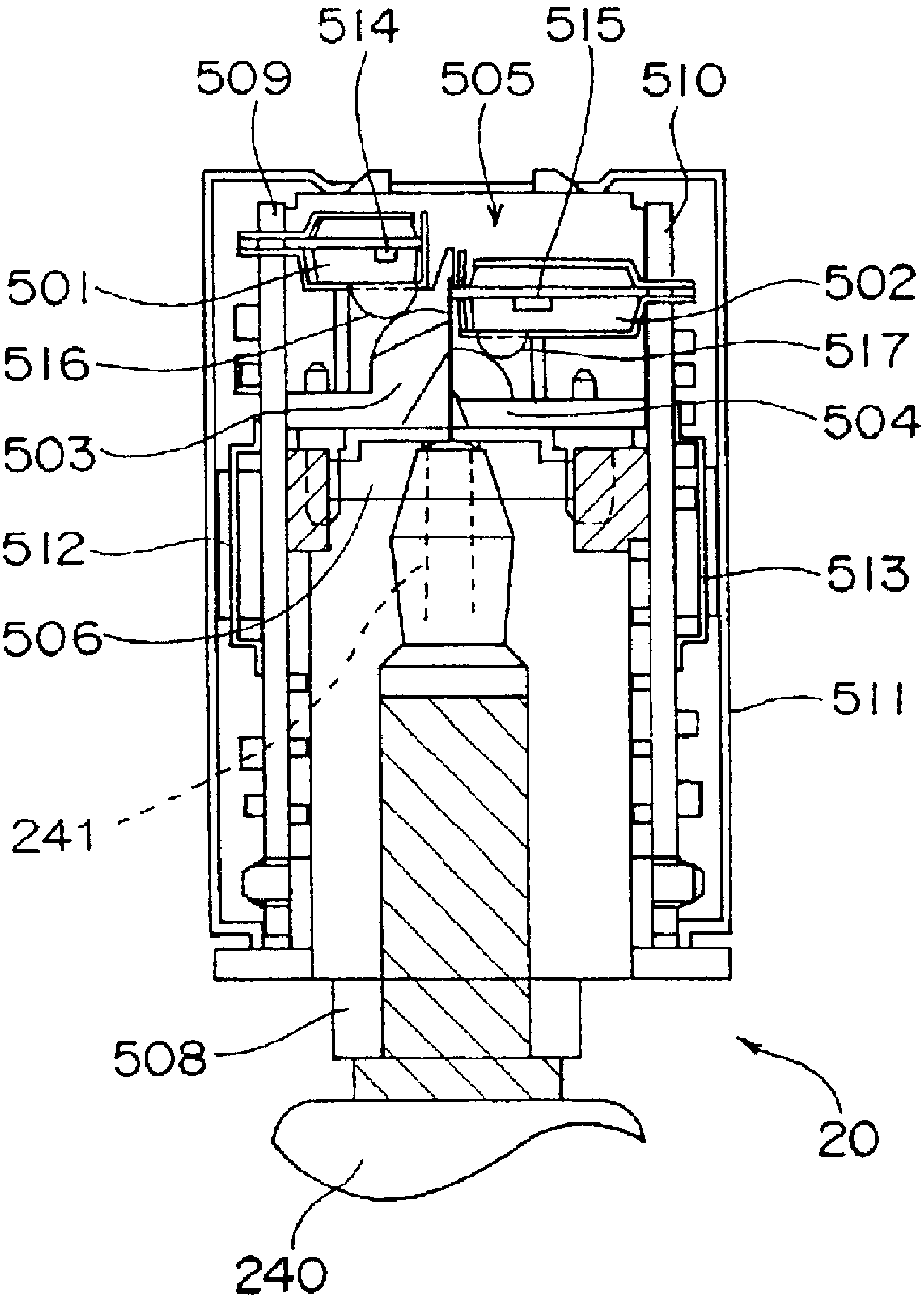
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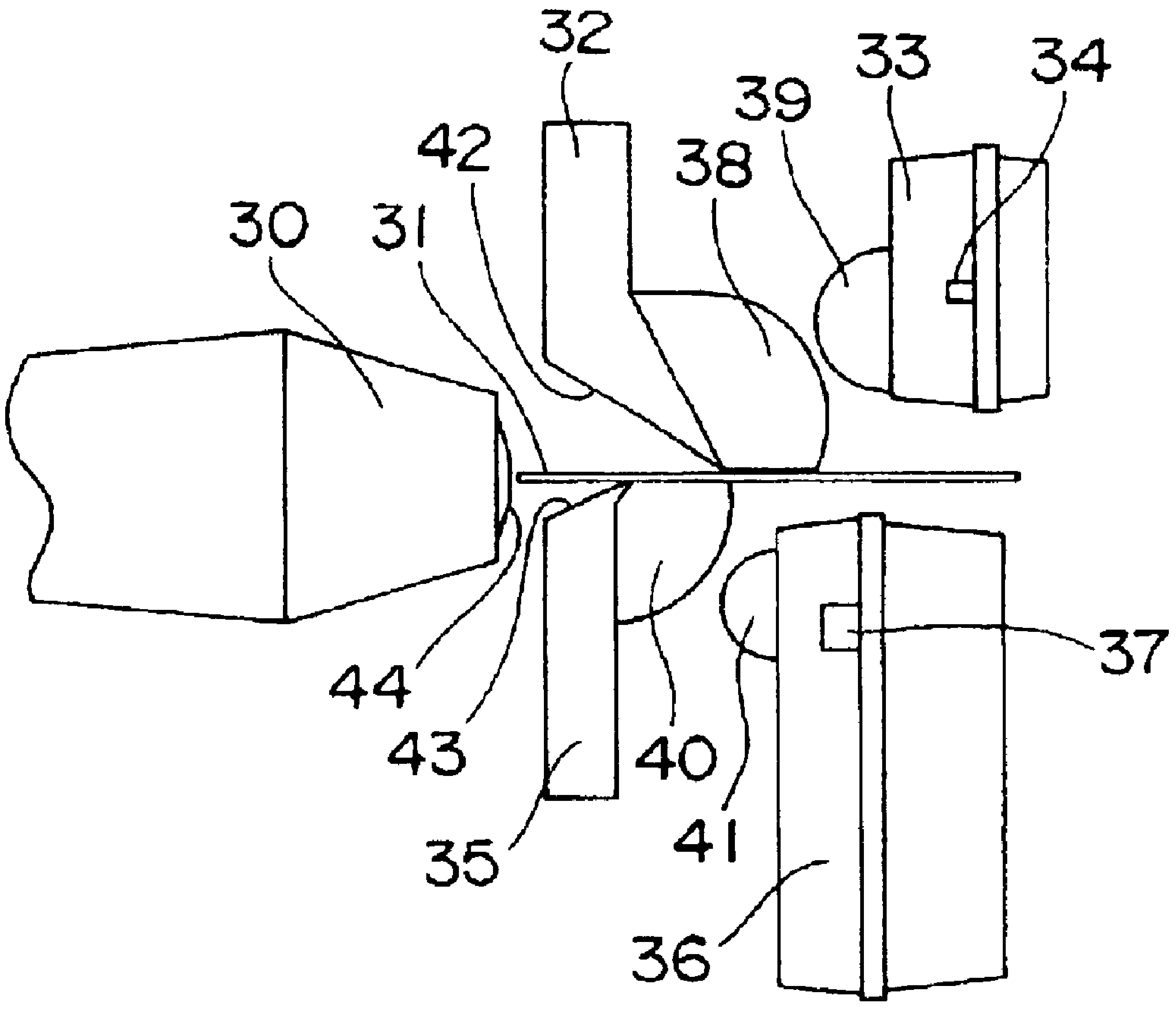
Fig.6



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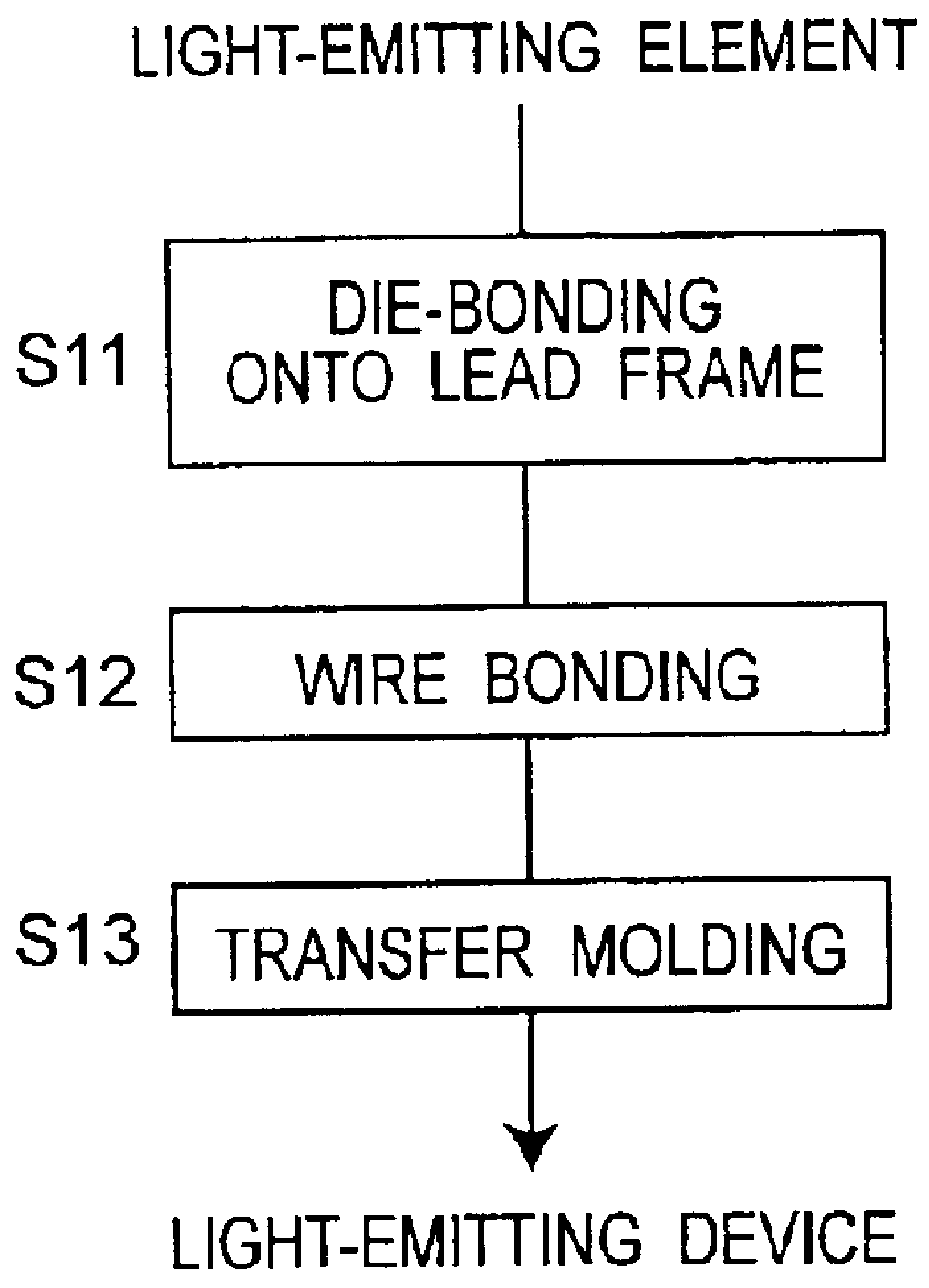

LIGHT-EMITTING ELEMENT
S11
DIE-BONDING ONTO LEAD FRAME
S12
WIRE BONDING
S13
TRANSFER MOLDING
LIGHT-EMITTING DEVICE

Fig.8

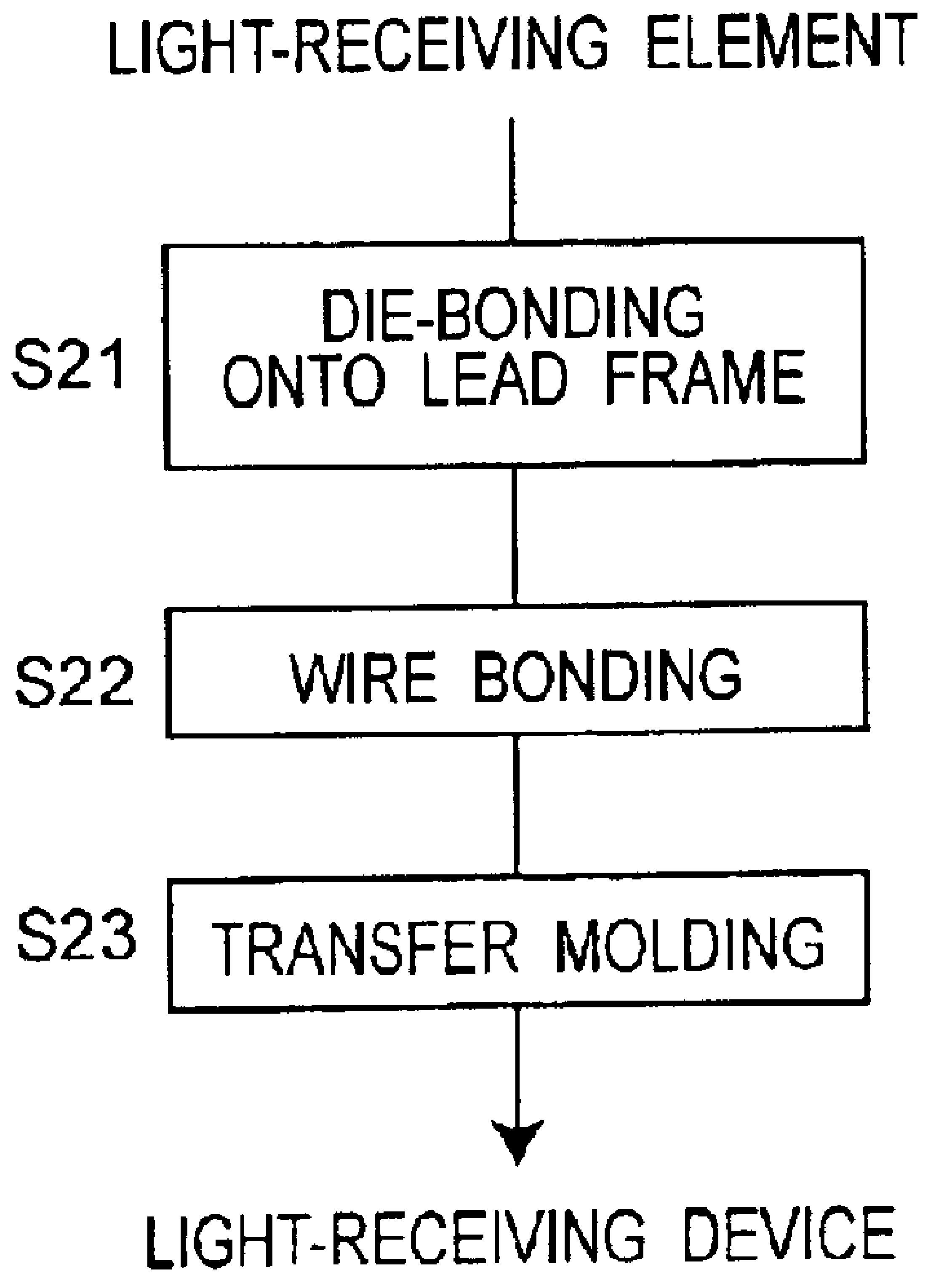
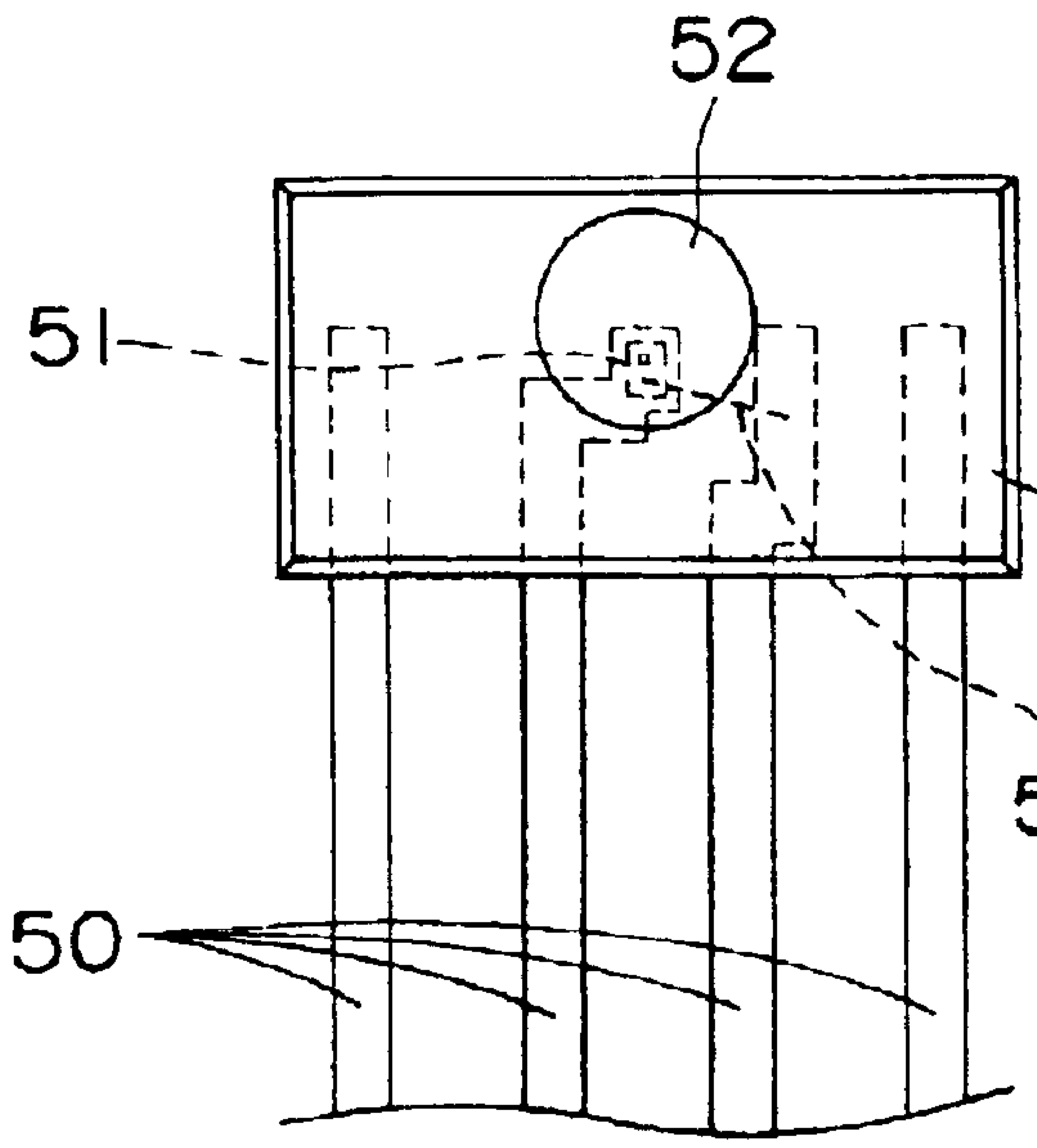

LIGHT-RECEIVING ELEMENT
S21
DIE-BONDING ONTO LEAD FRAME
S22
WIRE BONDING
S23
TRANSFER MOLDING
LIGHT-RECEIVING DEVICE

Fig.9A



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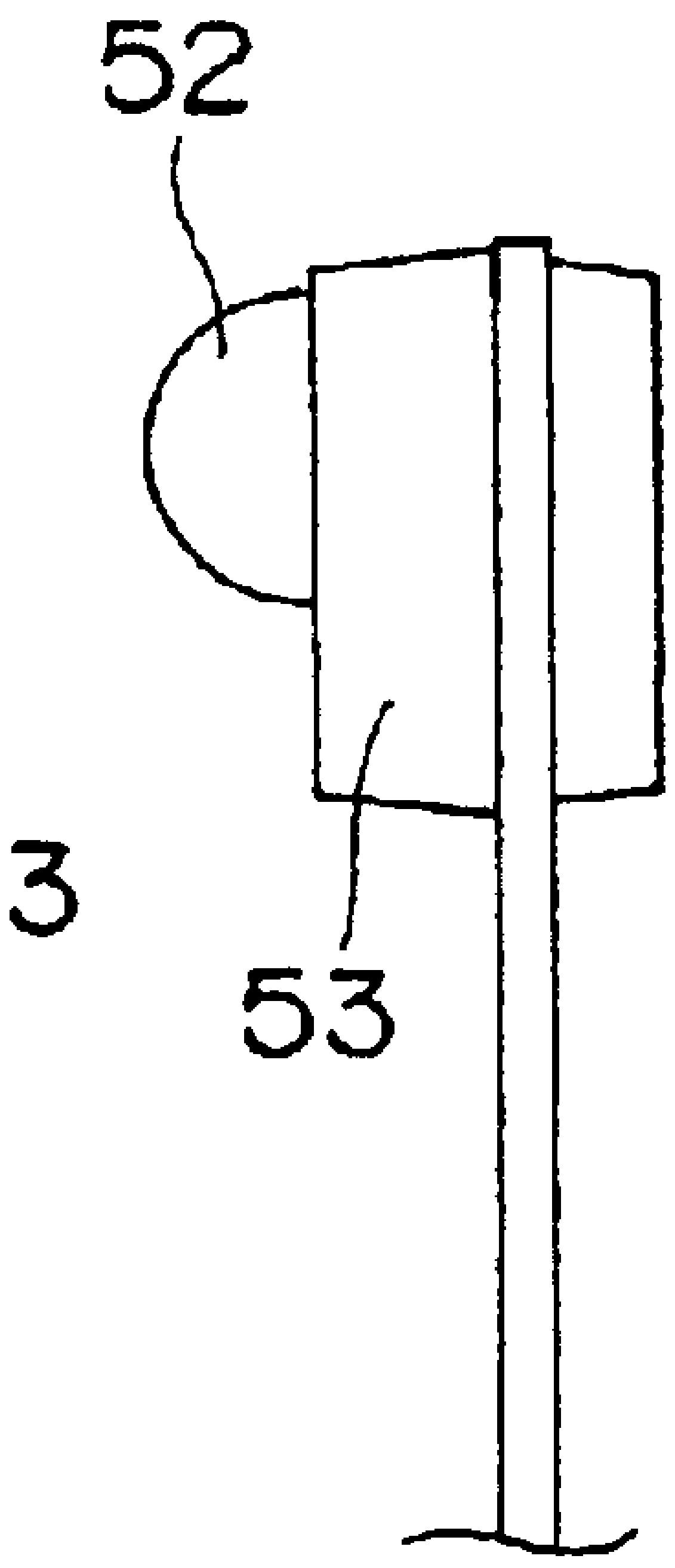


Fig.10A

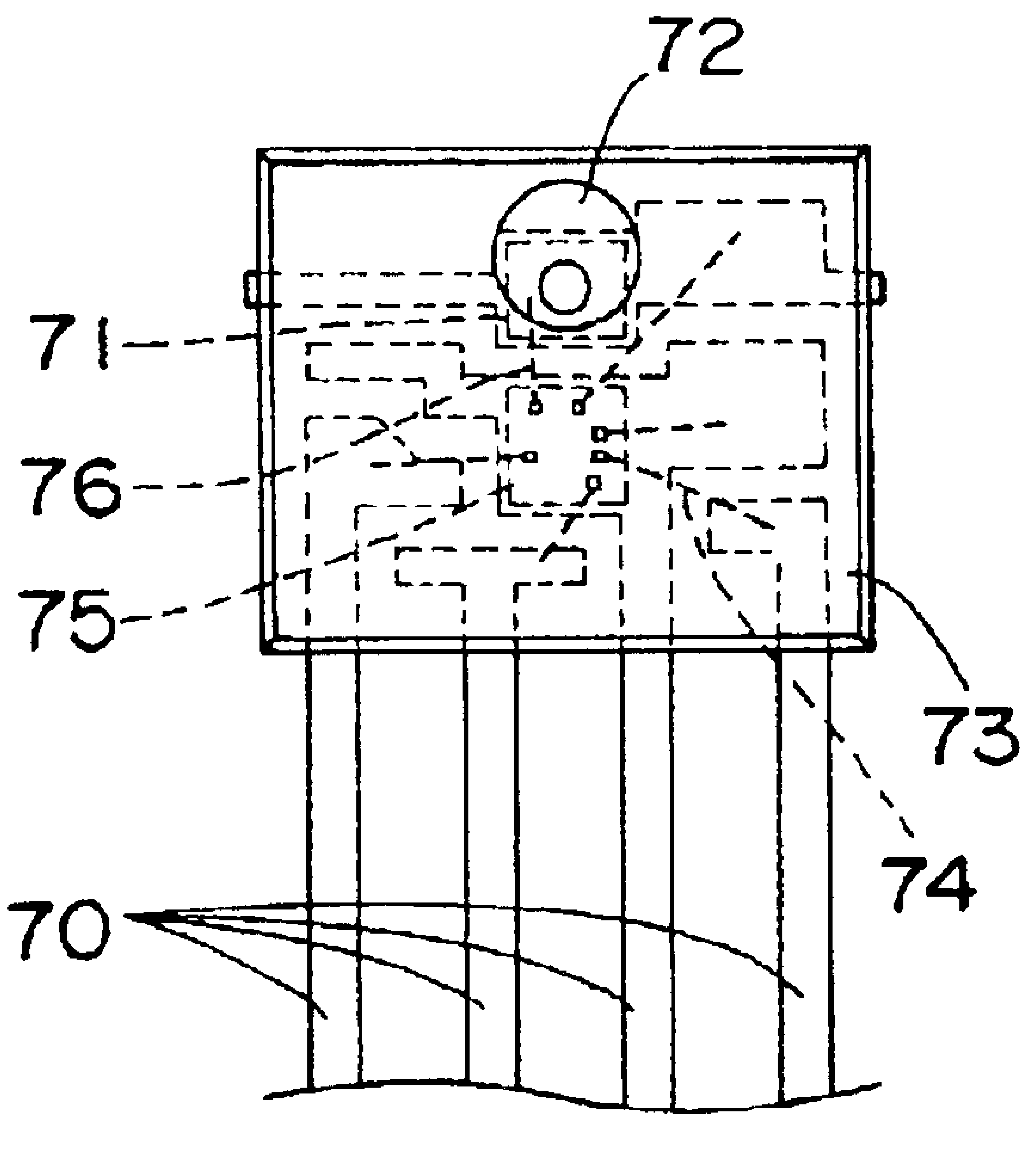


Fig.10B

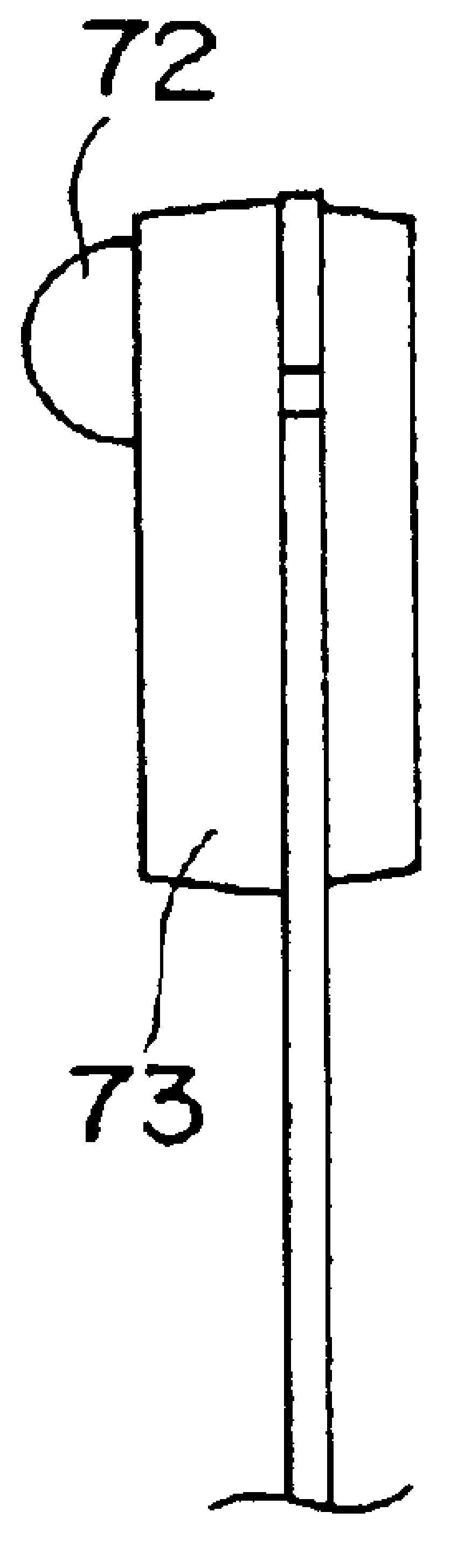


Fig. 11

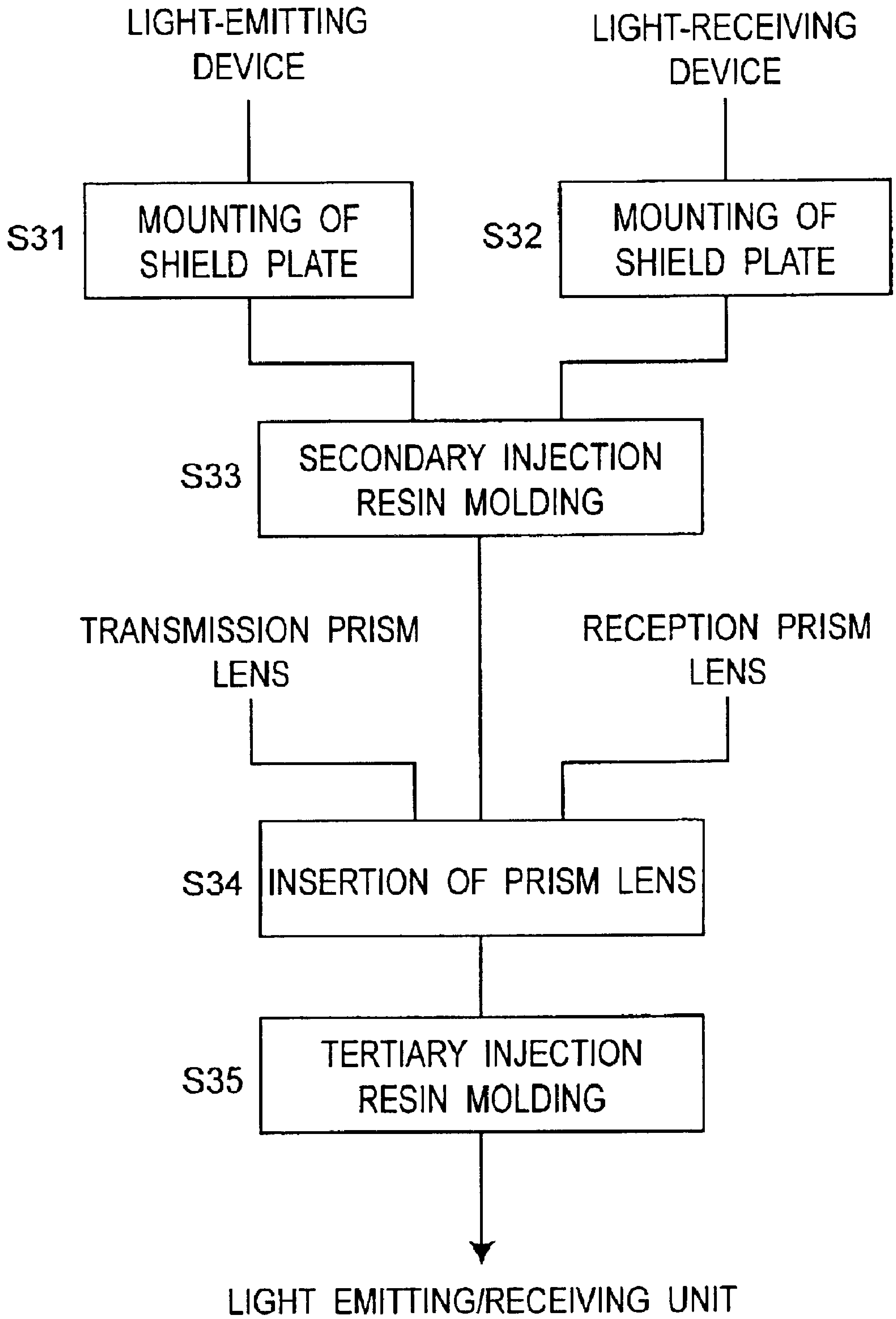

LIGHT-EMITTING DEVICE
LIGHT-RECEIVING DEVICE
S31
MOUNTING OF SHIELD PLATE
S32
MOUNTING OF SHIELD PLATE
S33
SECONDARY INJECTION RESIN MOLDING
TRANSMISSION PRISM LENS
RECEPTION PRISM LENS
S34
INSERTION OF PRISM LENS
S35
TERTIARY INJECTION RESIN MOLDING
LIGHT EMITTING/RECEIVING UNIT

Fig. 12A

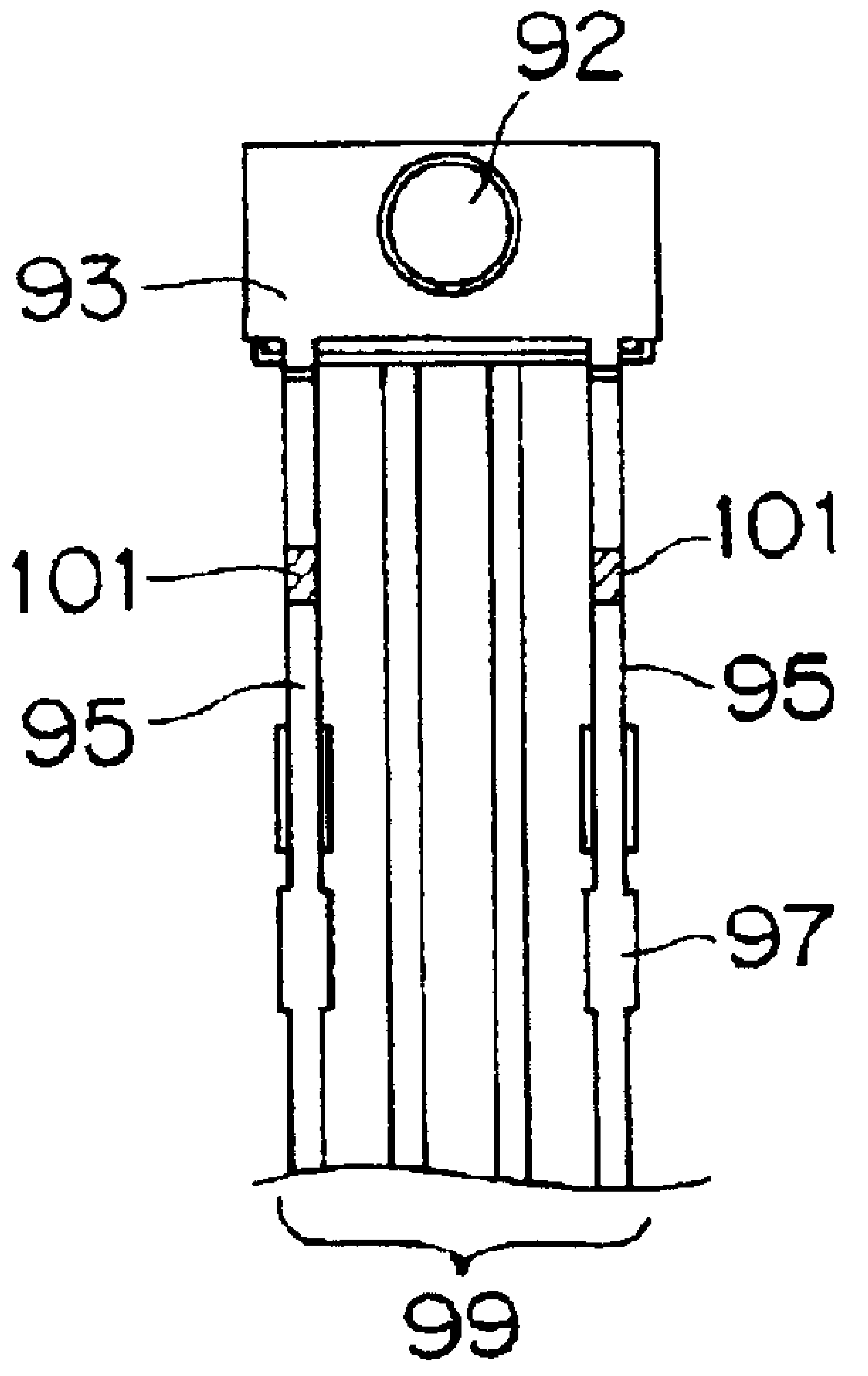


Fig. 12B

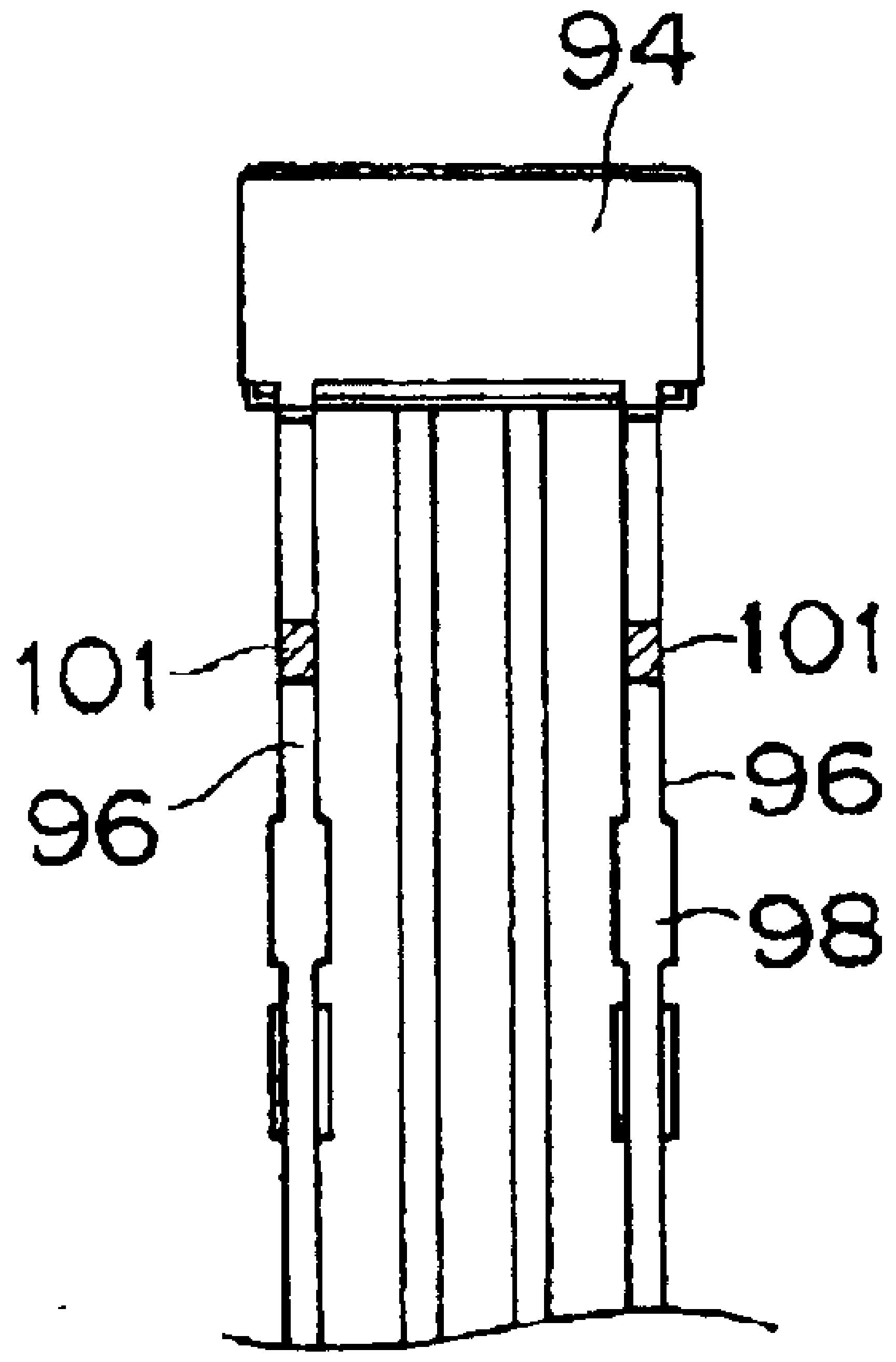
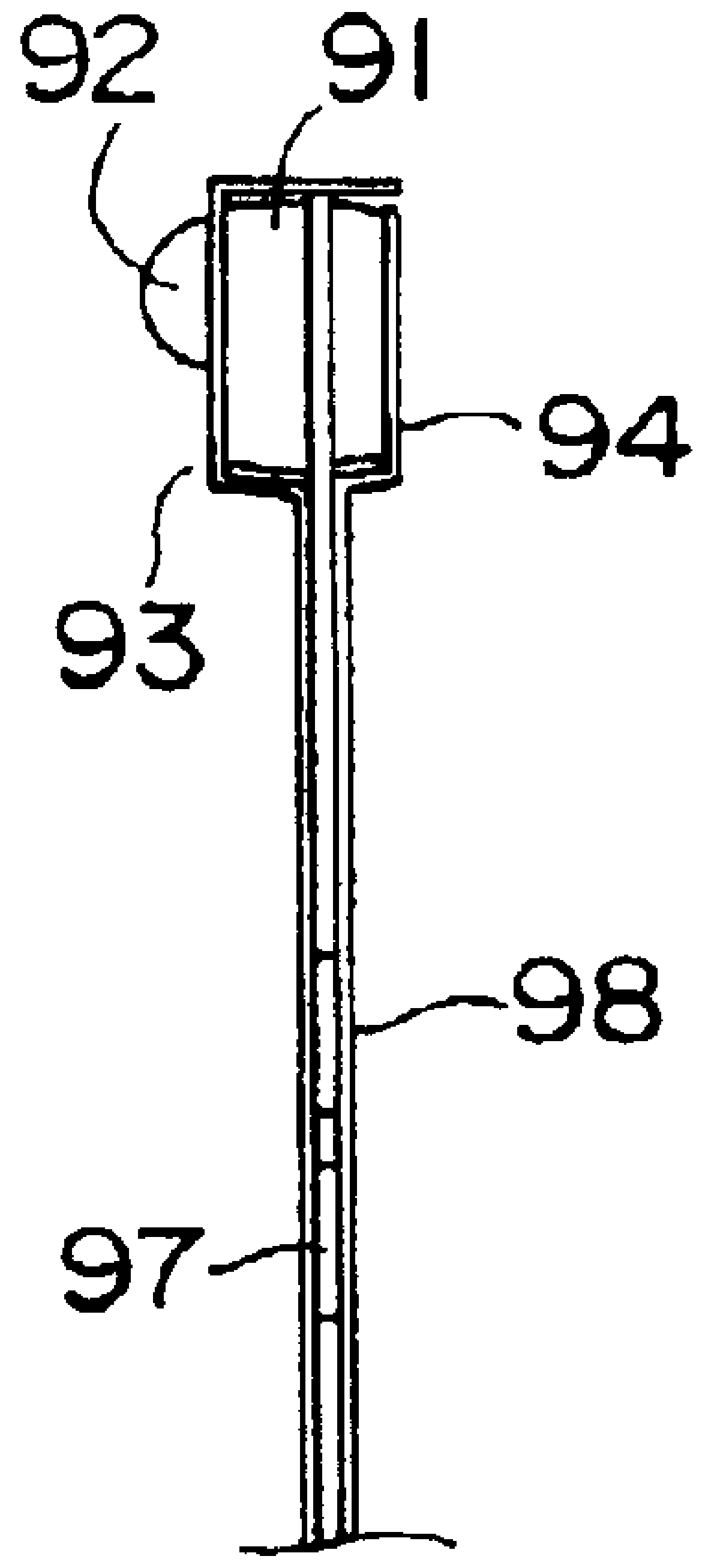


Fig. 12C



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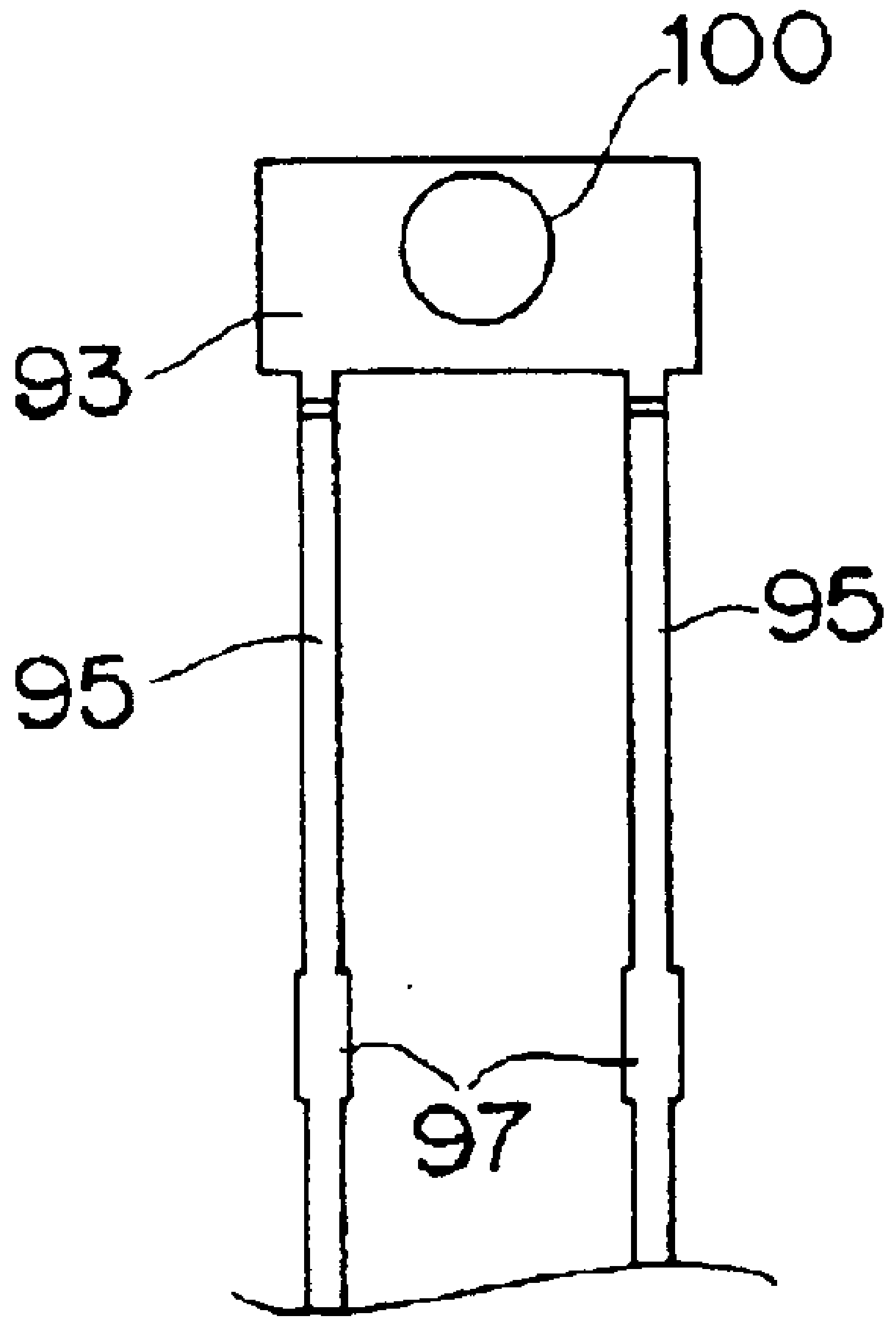

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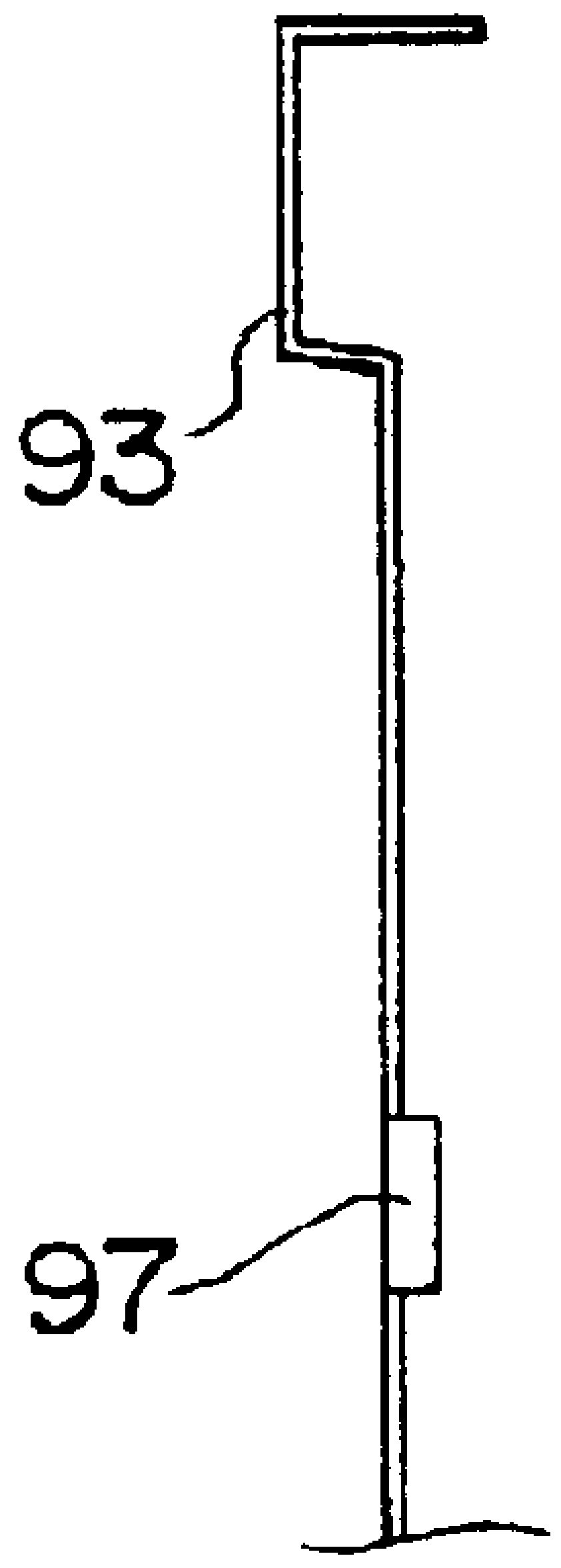

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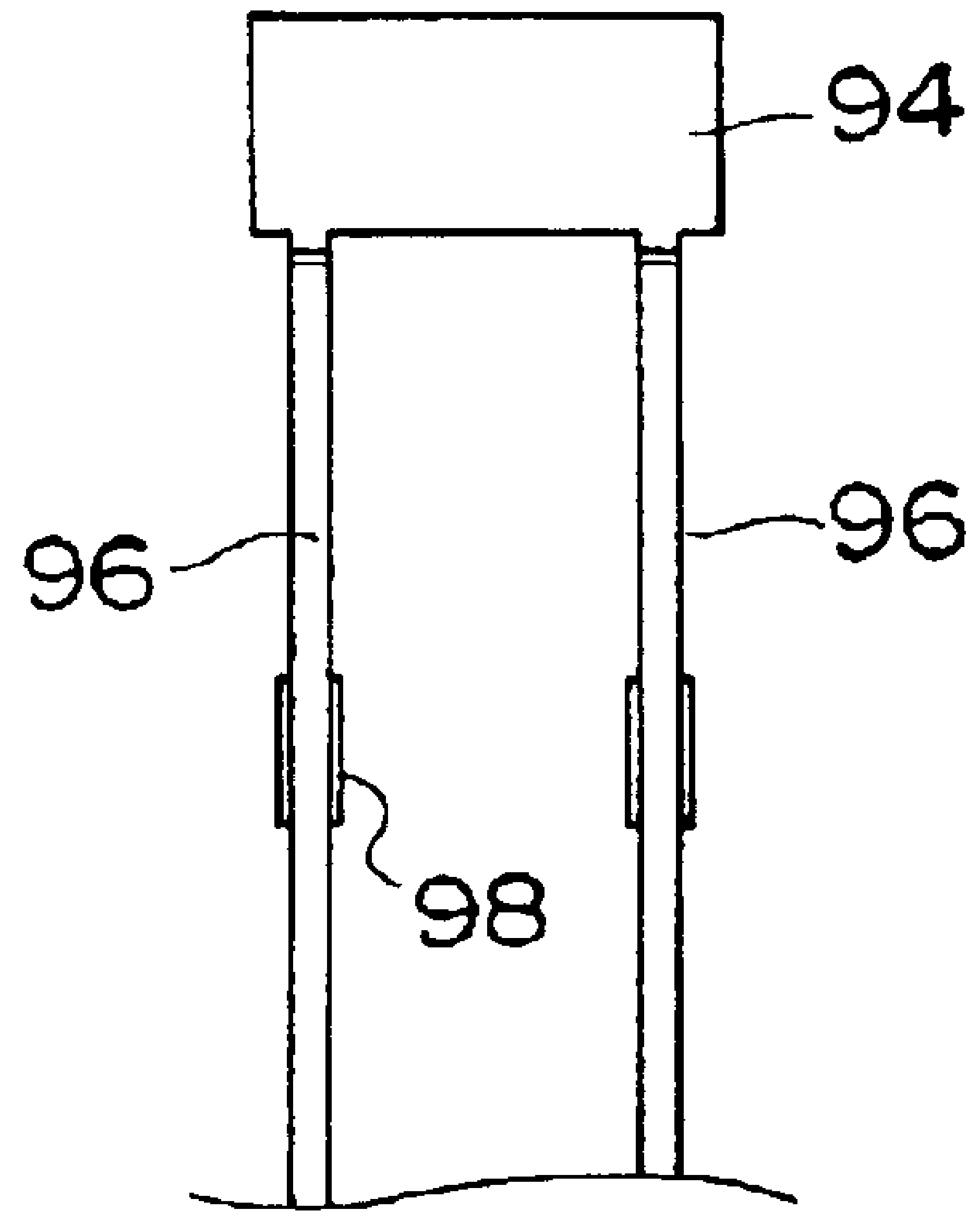


Fig.14B

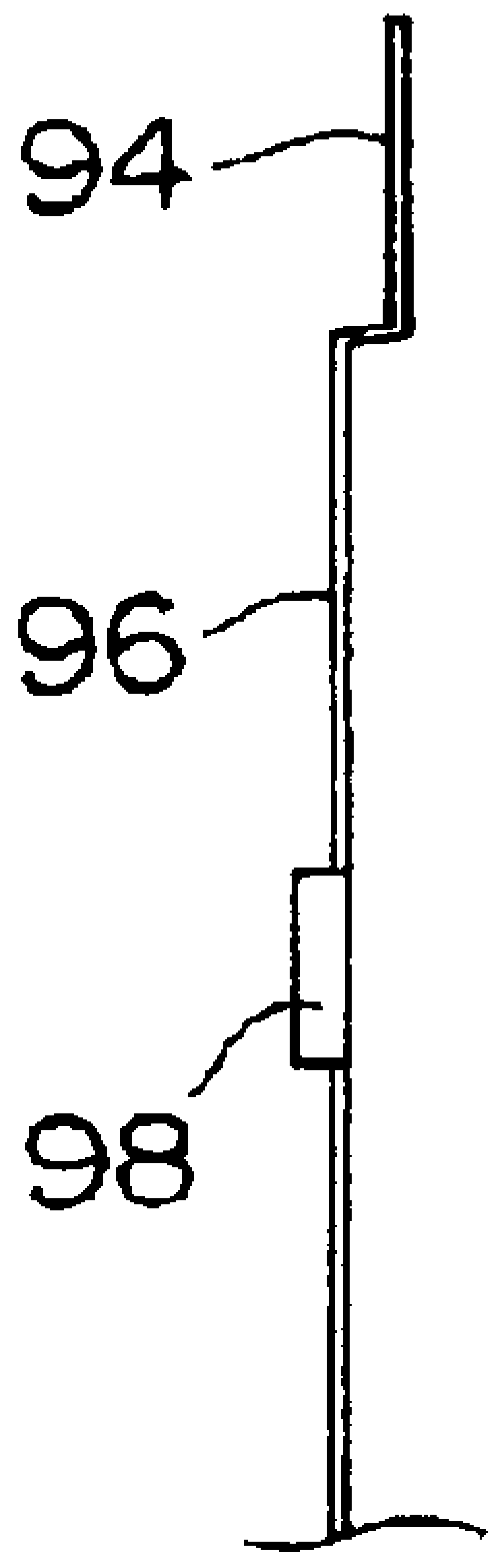
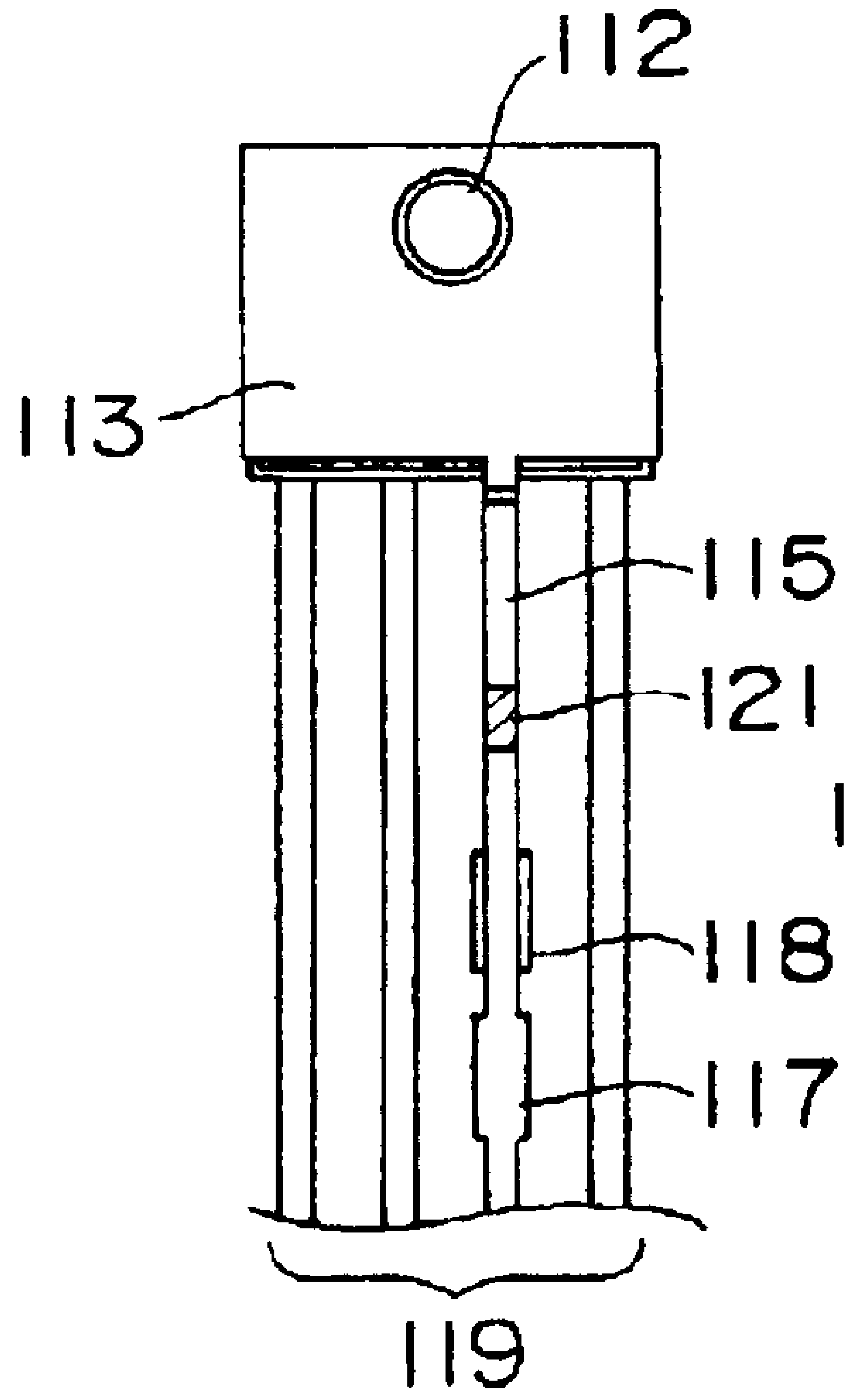


Fig.15A



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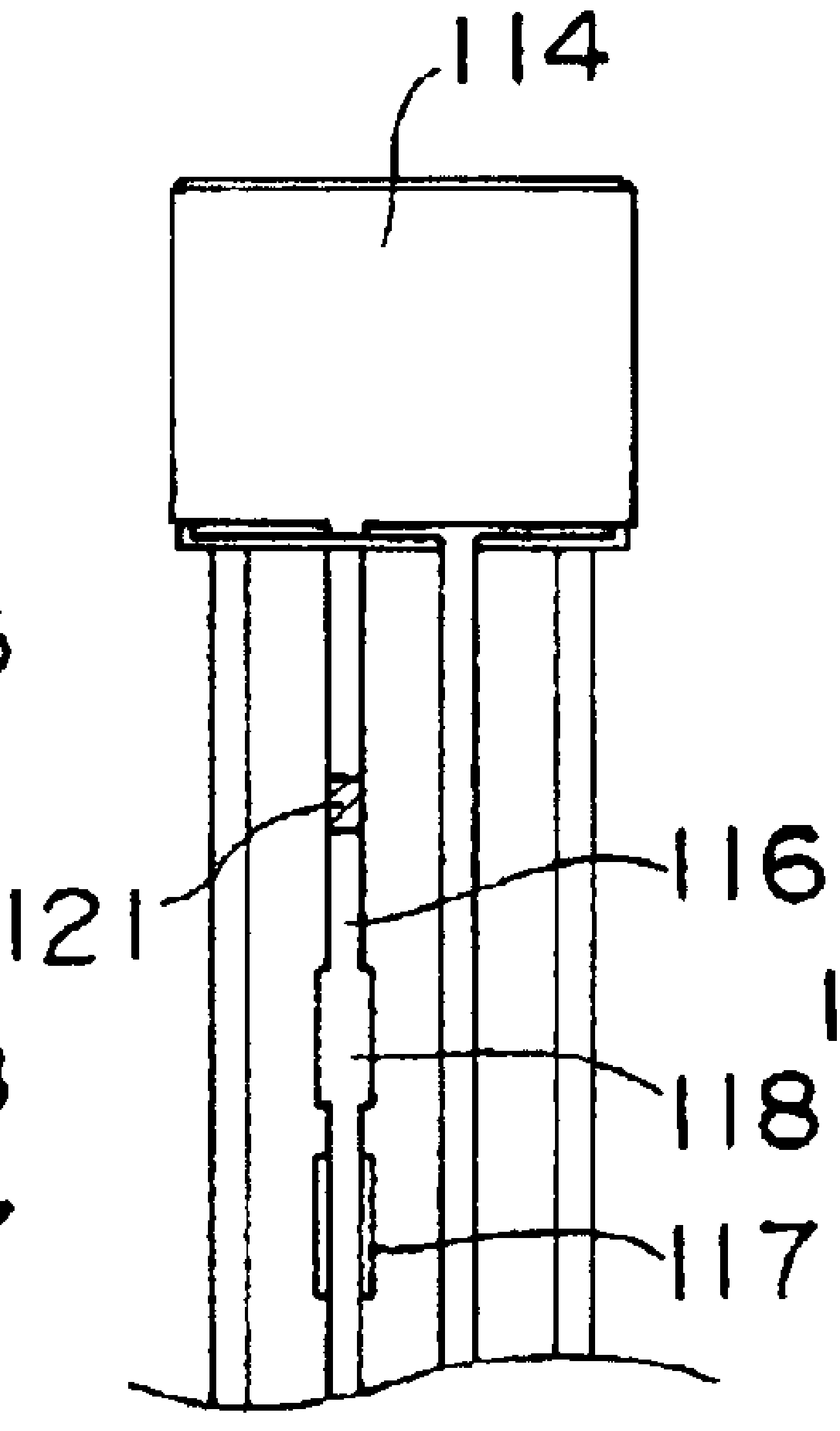

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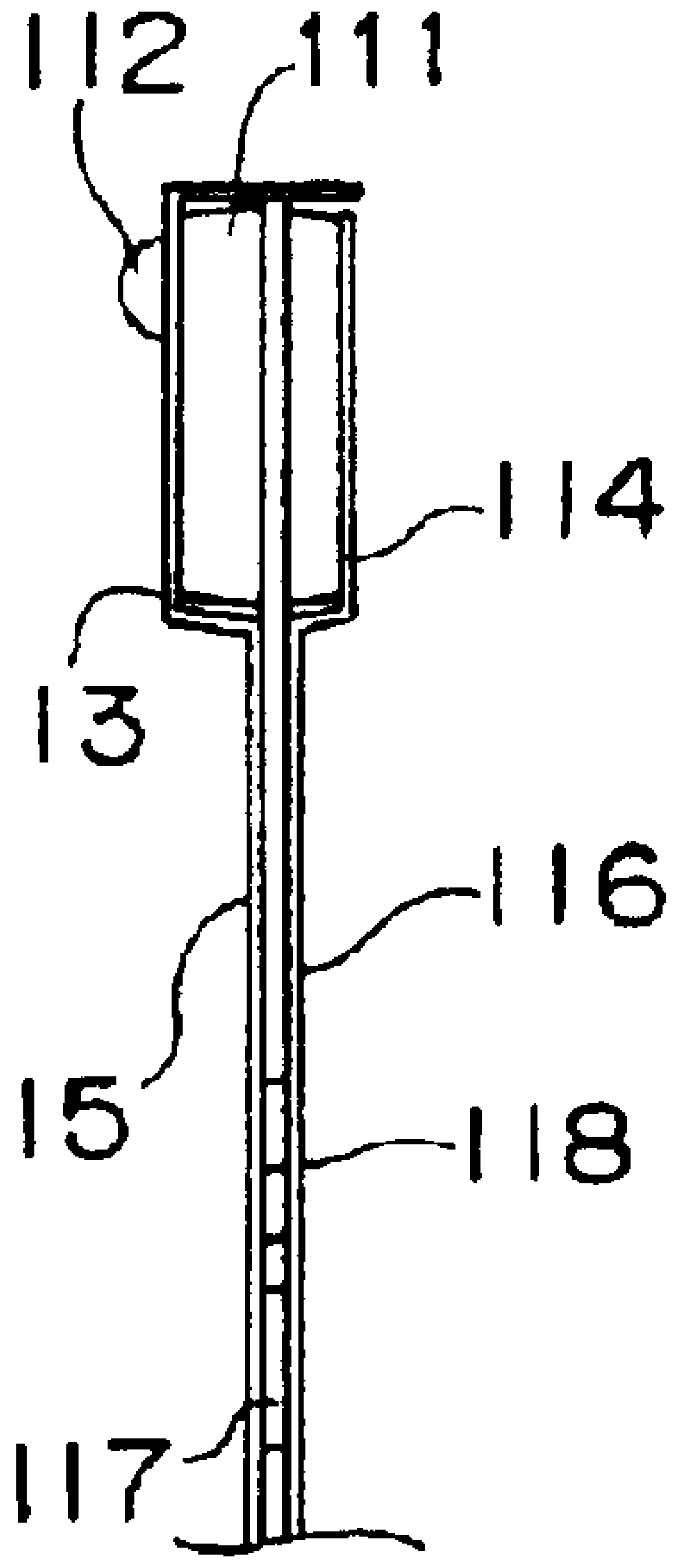

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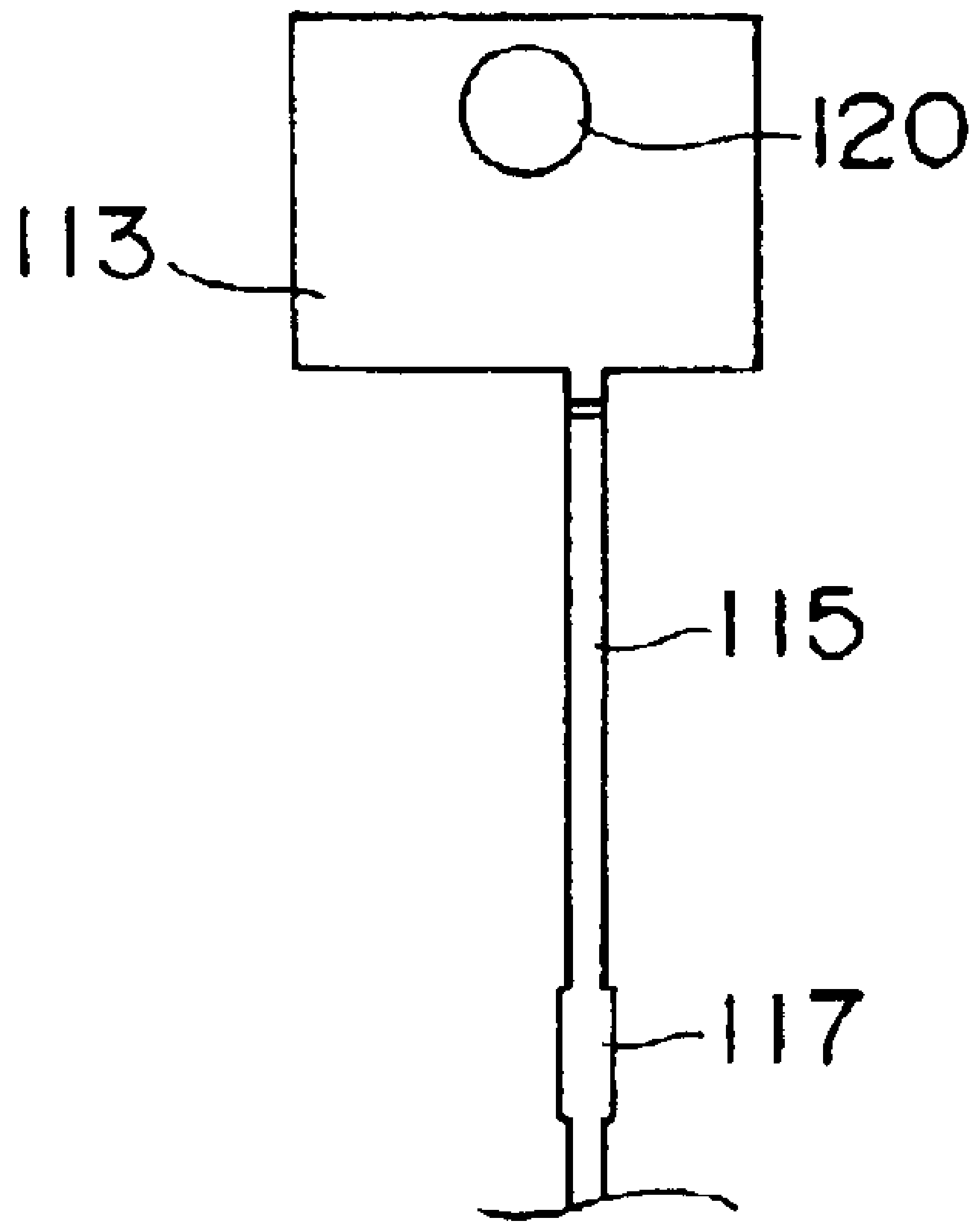

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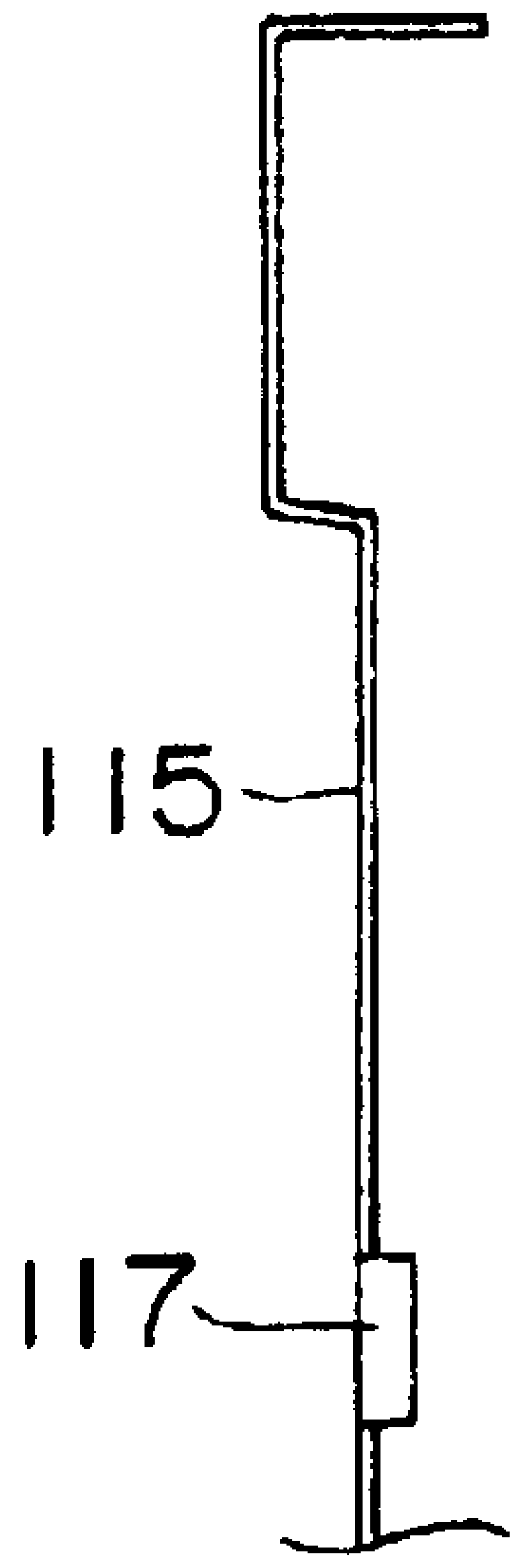

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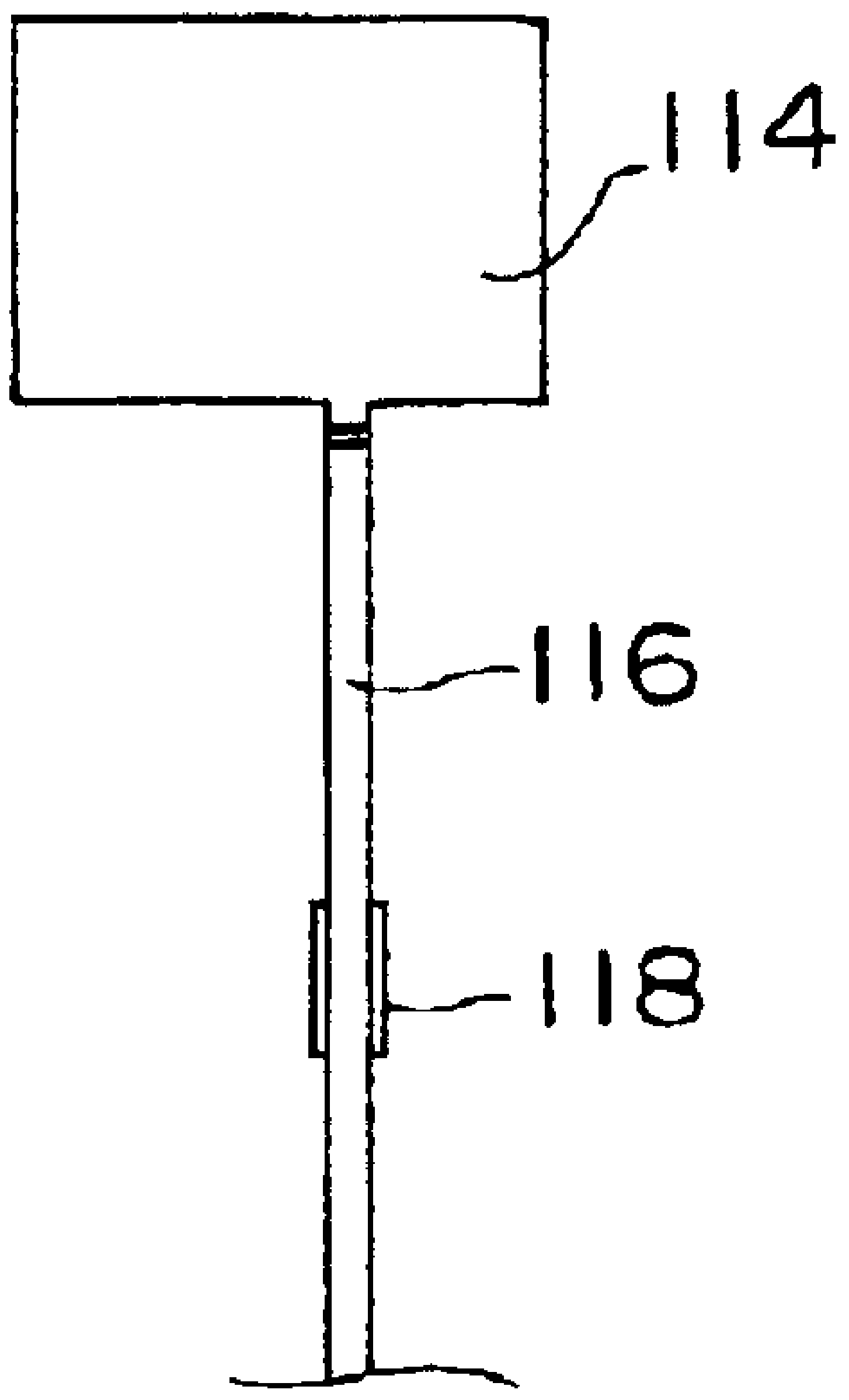

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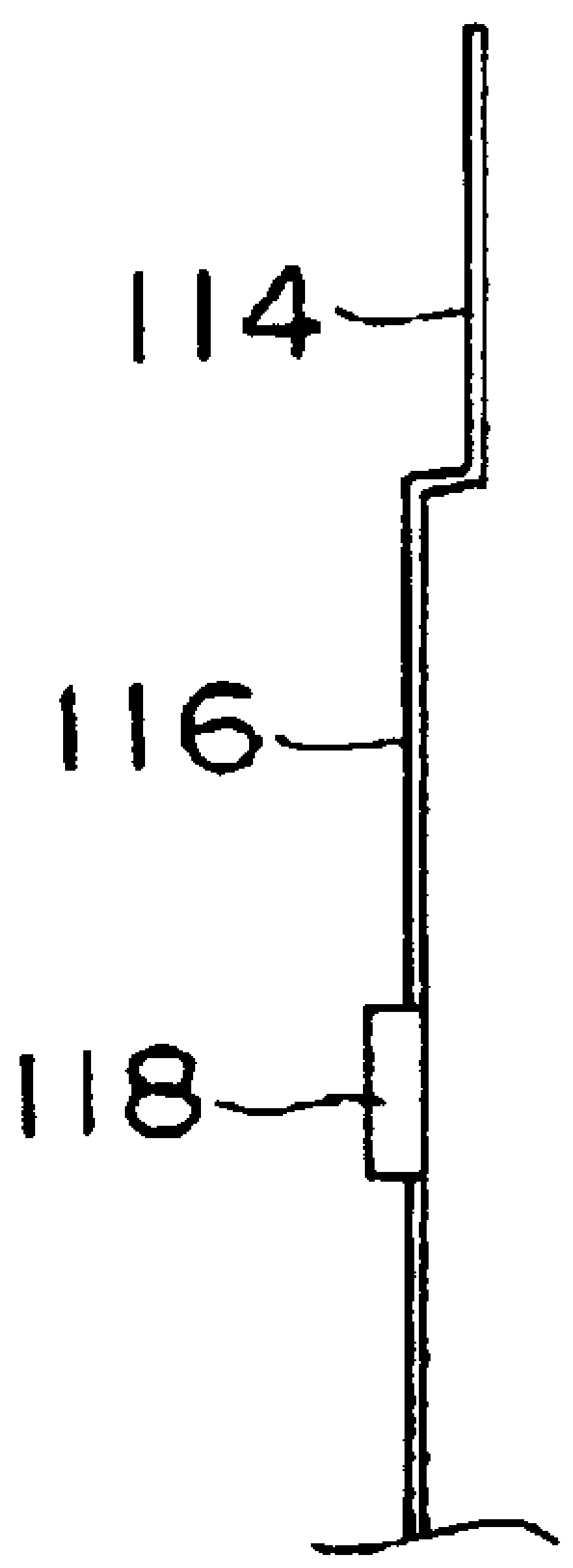

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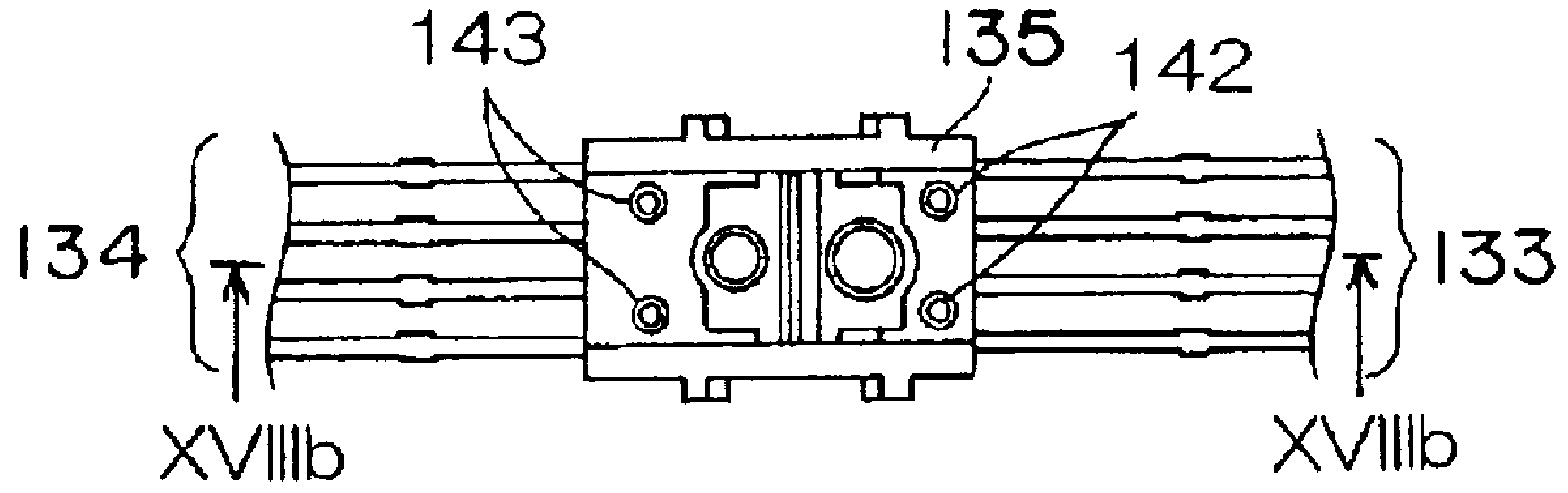

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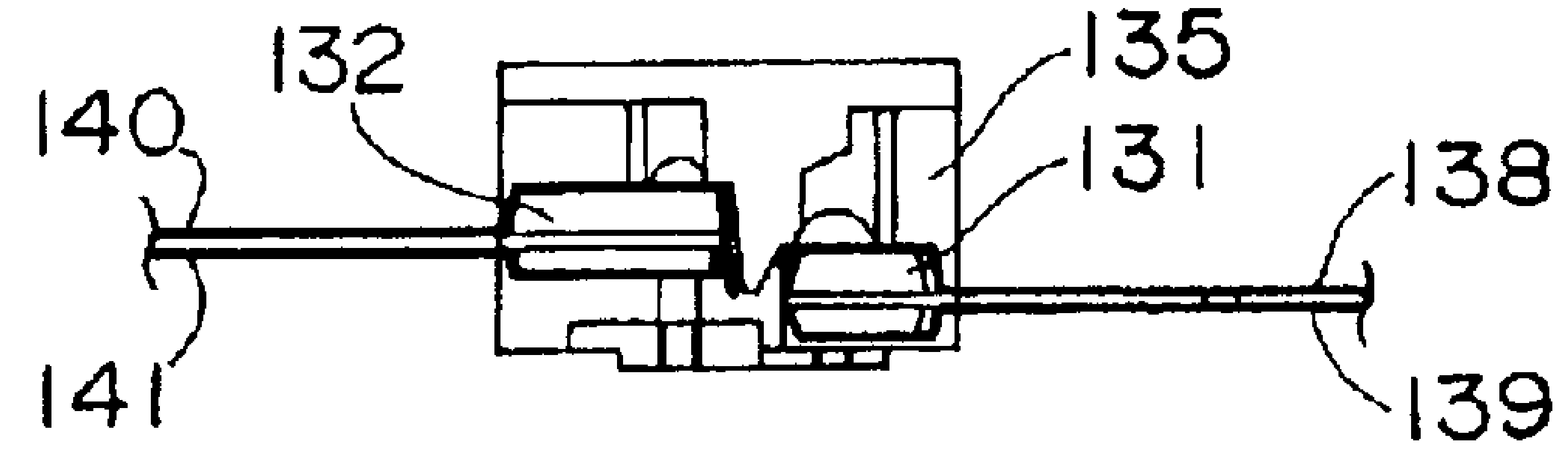

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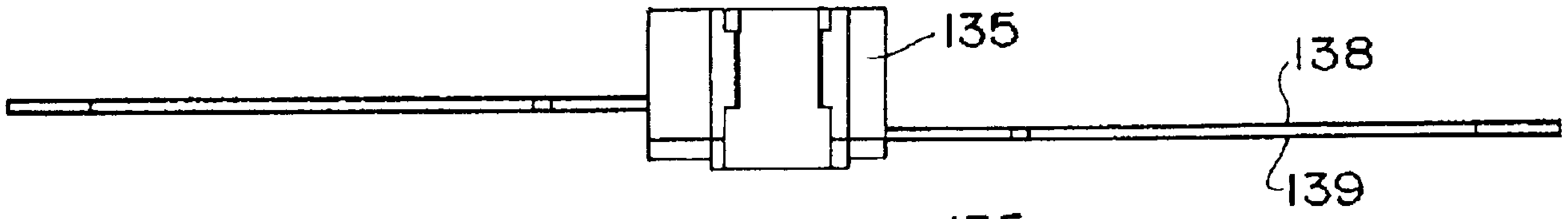

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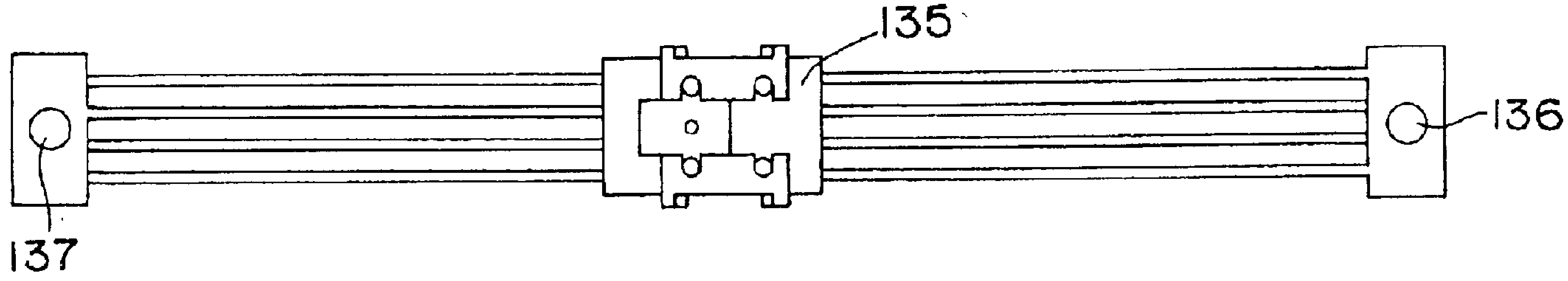

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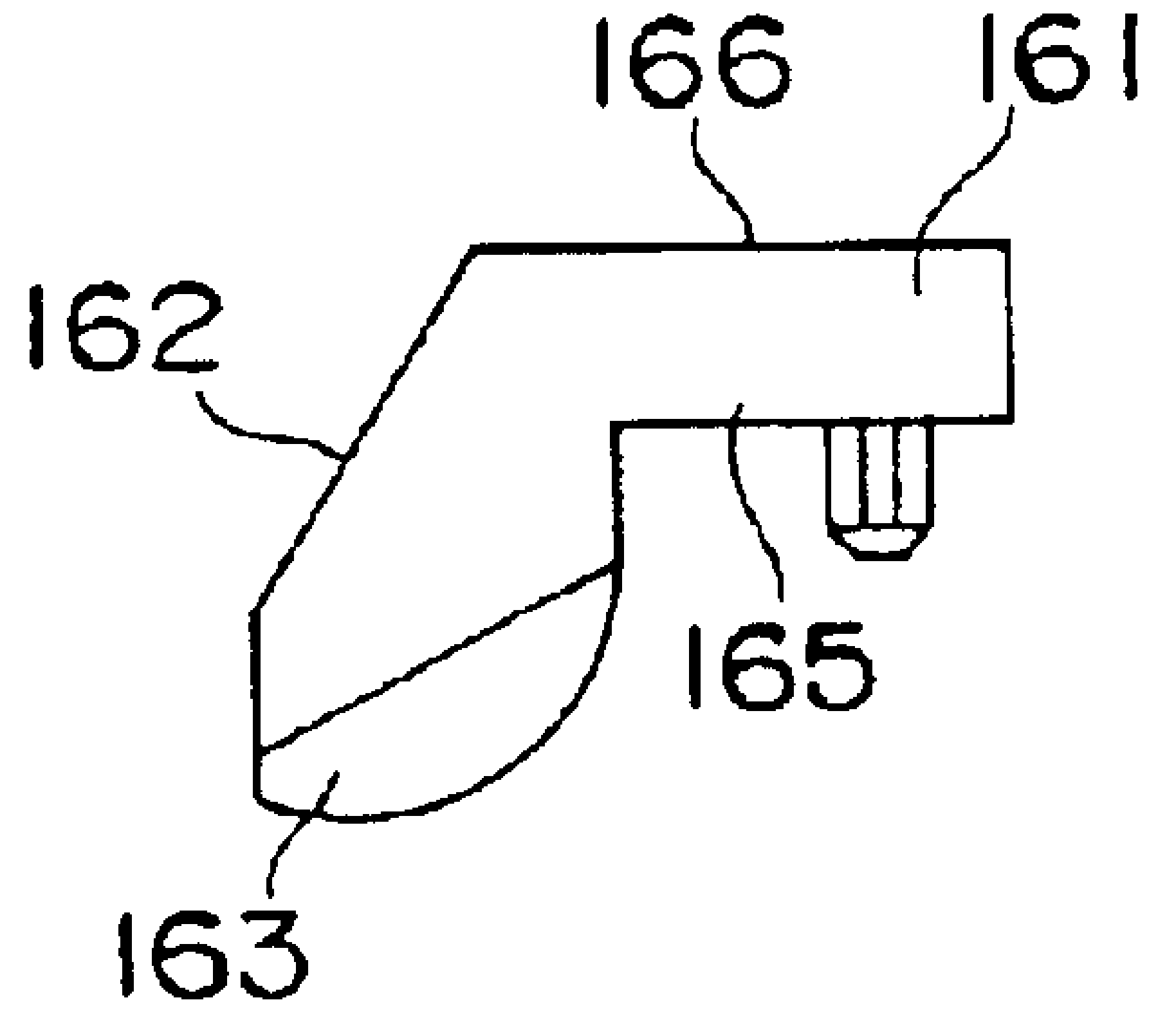

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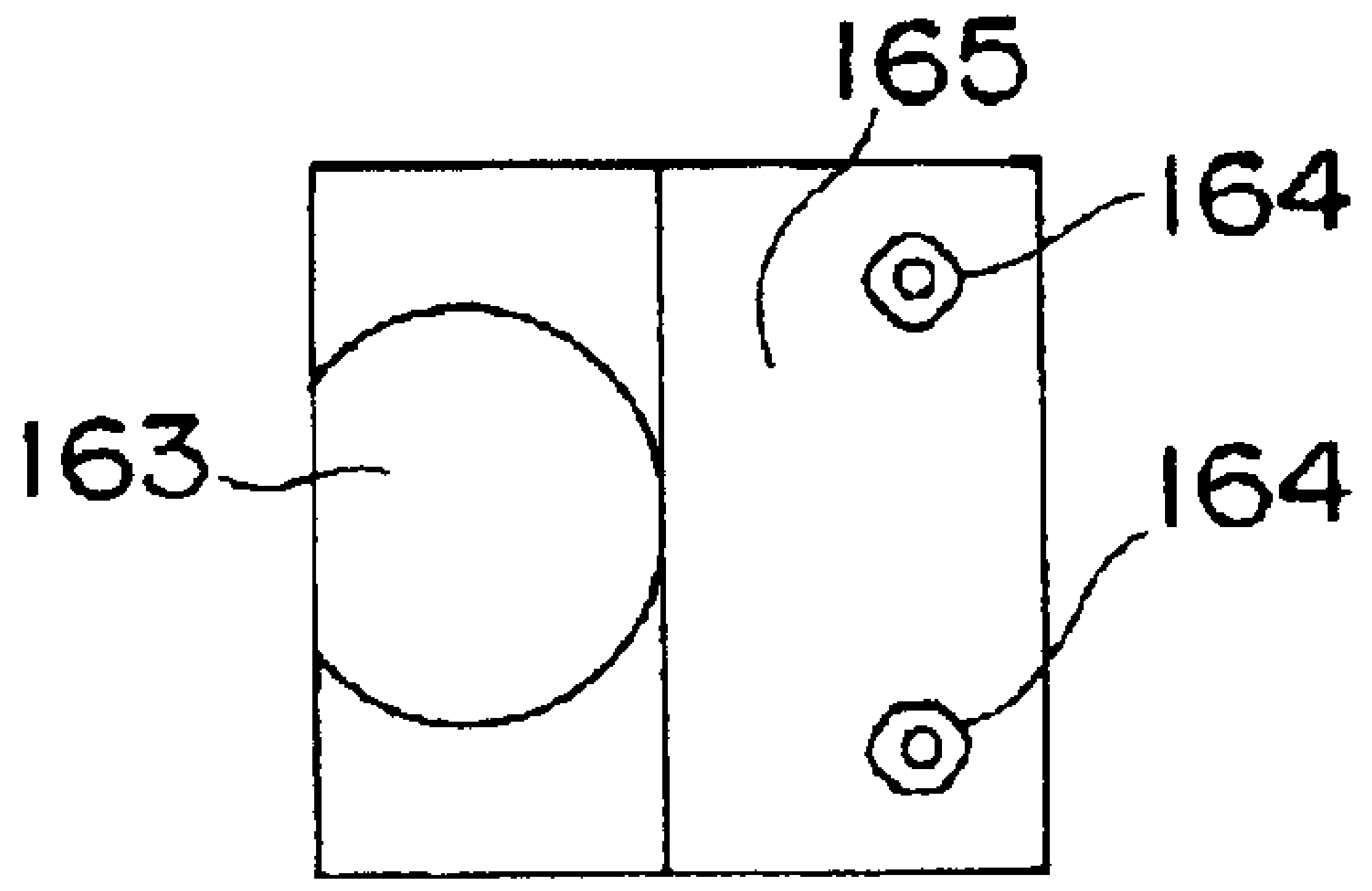


Fig. 19C

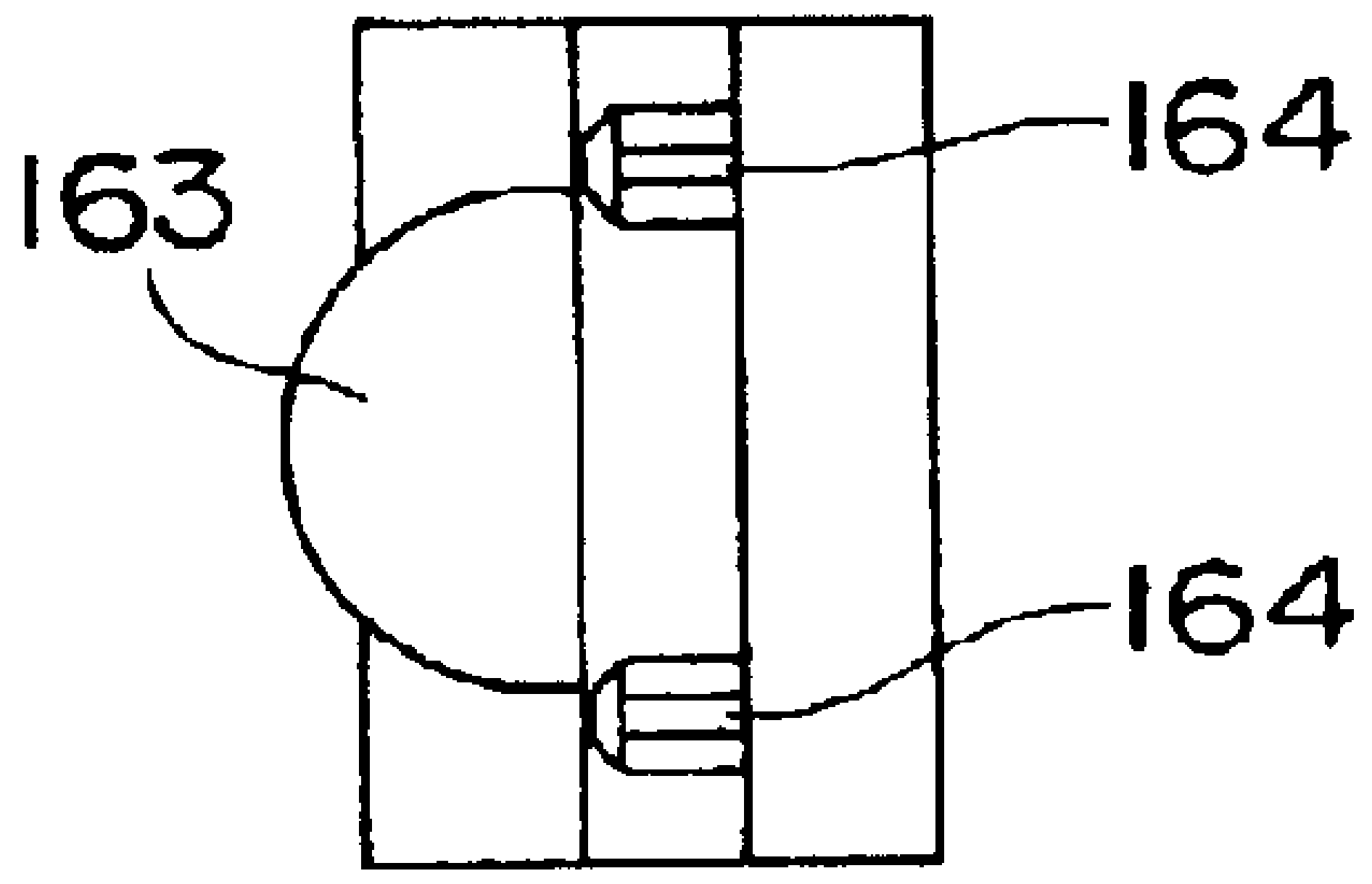


Fig. 20B

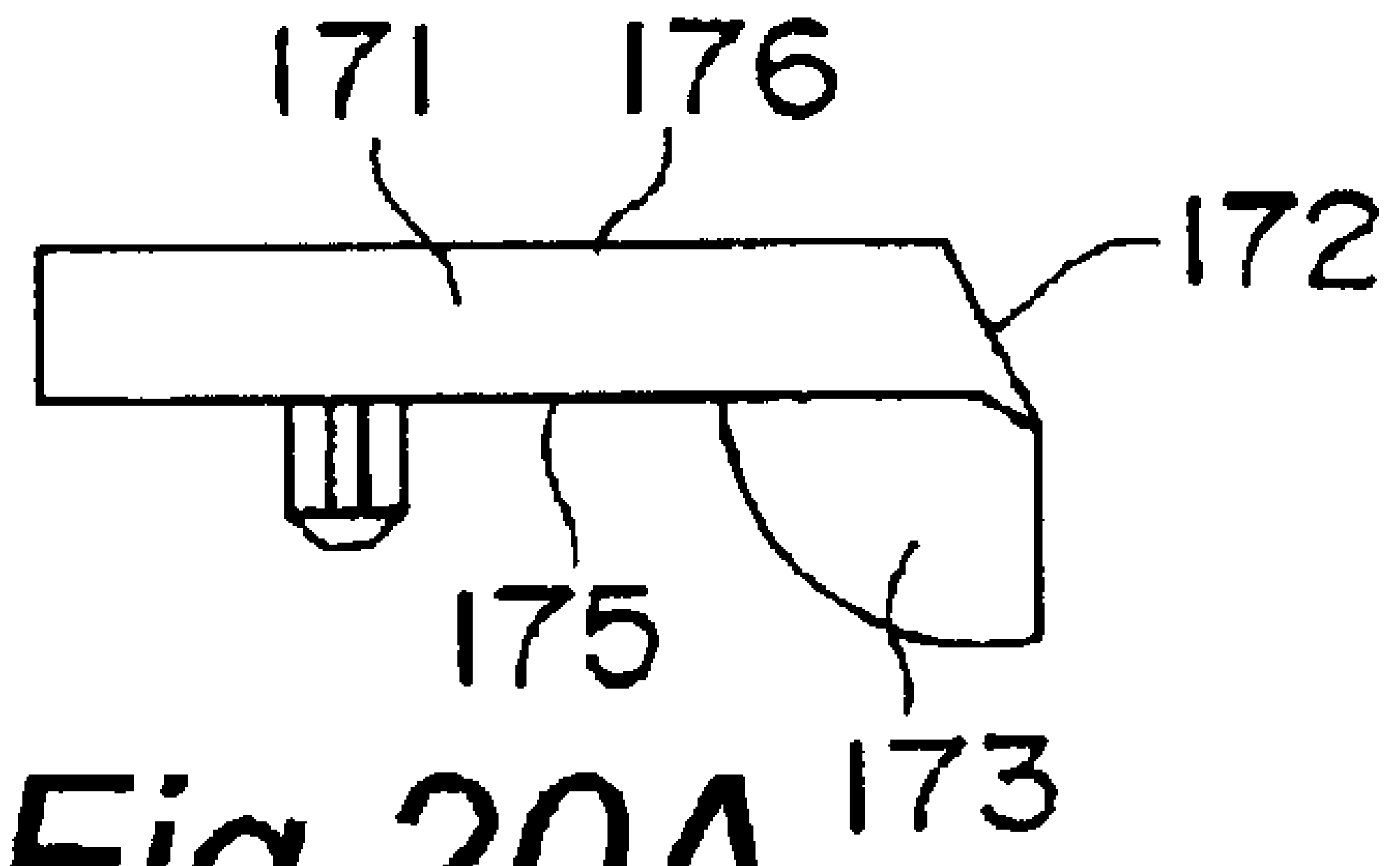
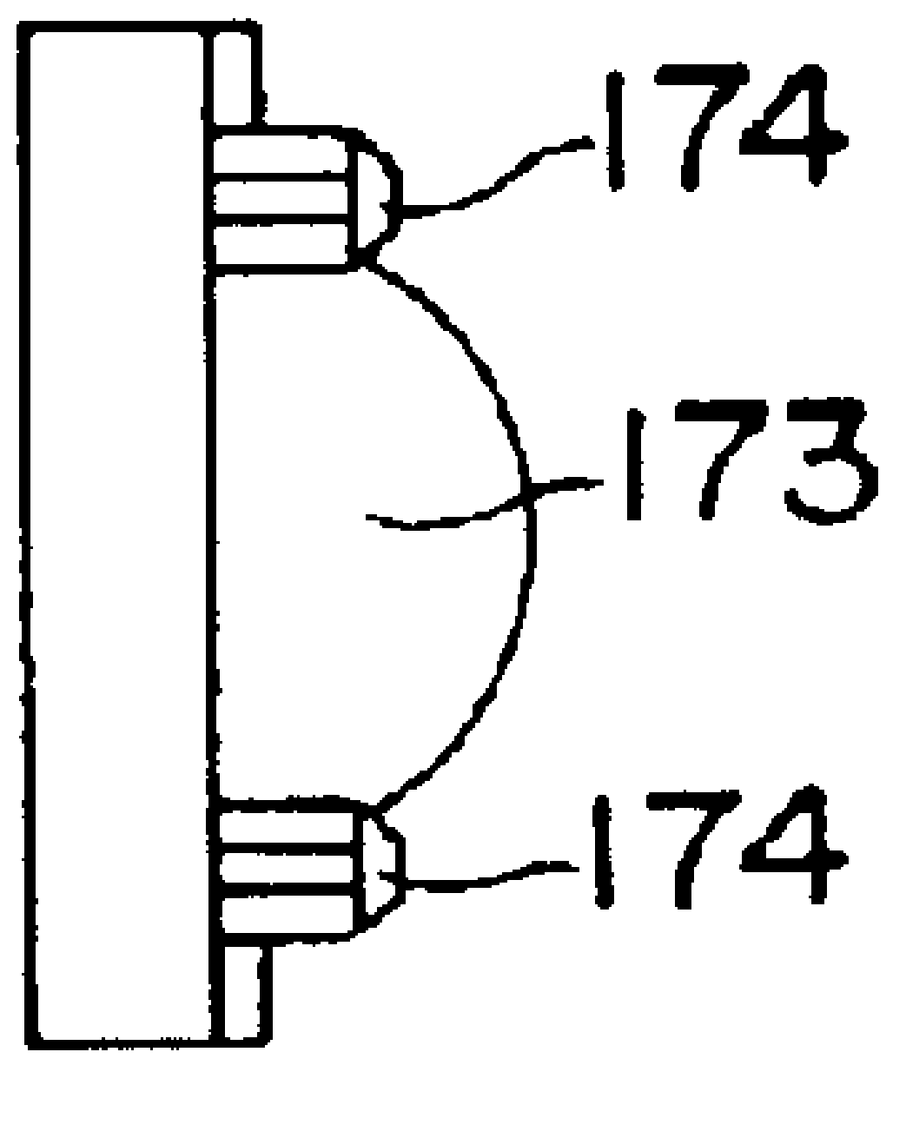


Fig. 20C



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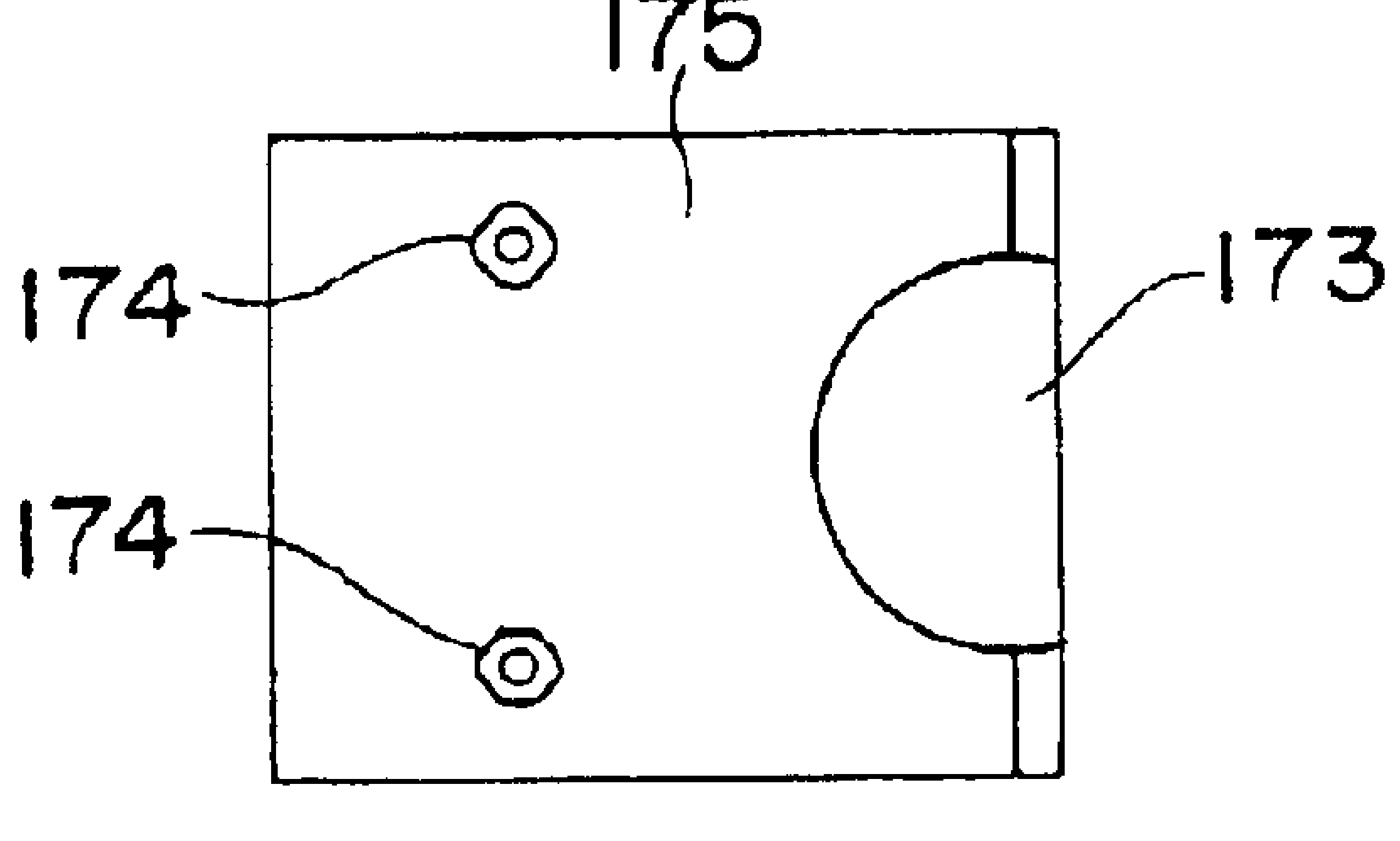

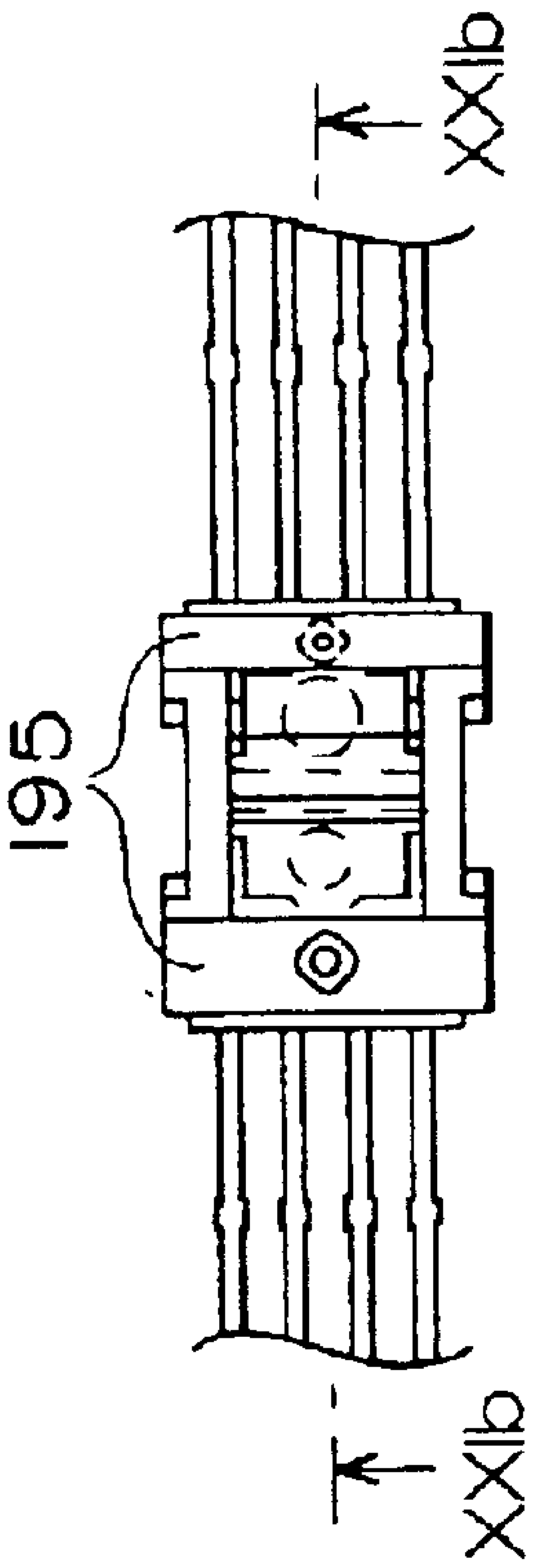

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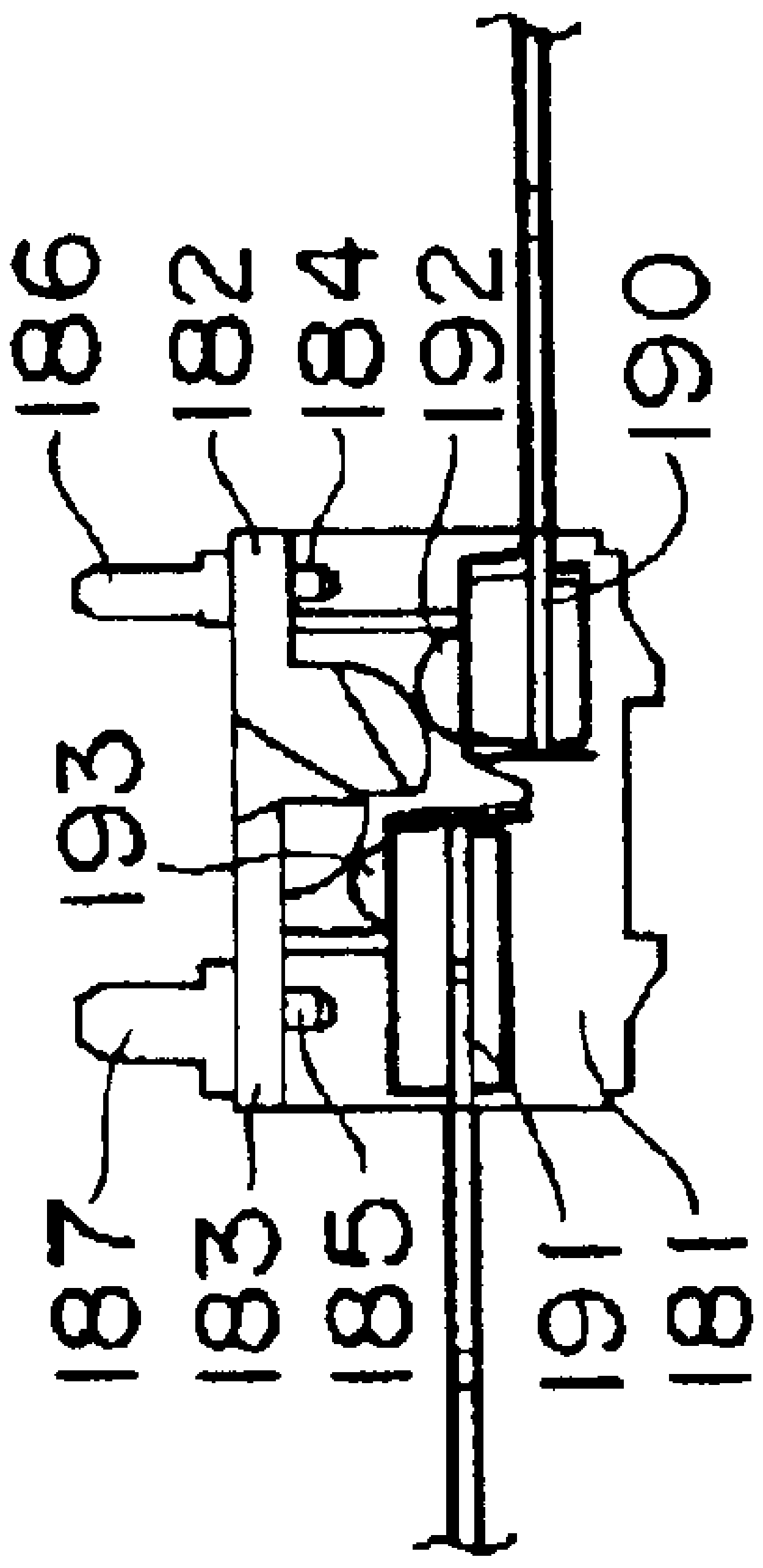

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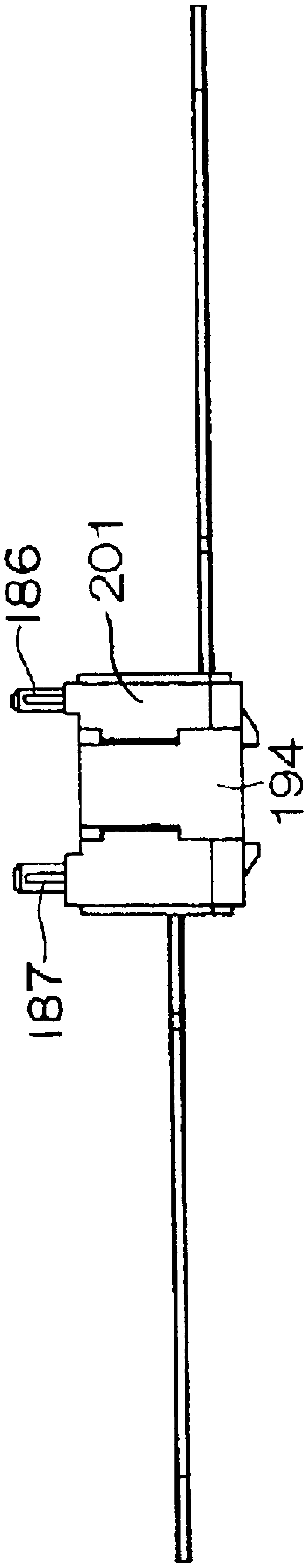

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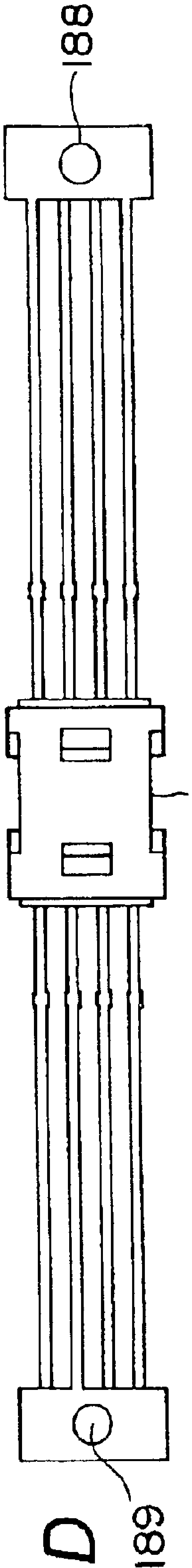

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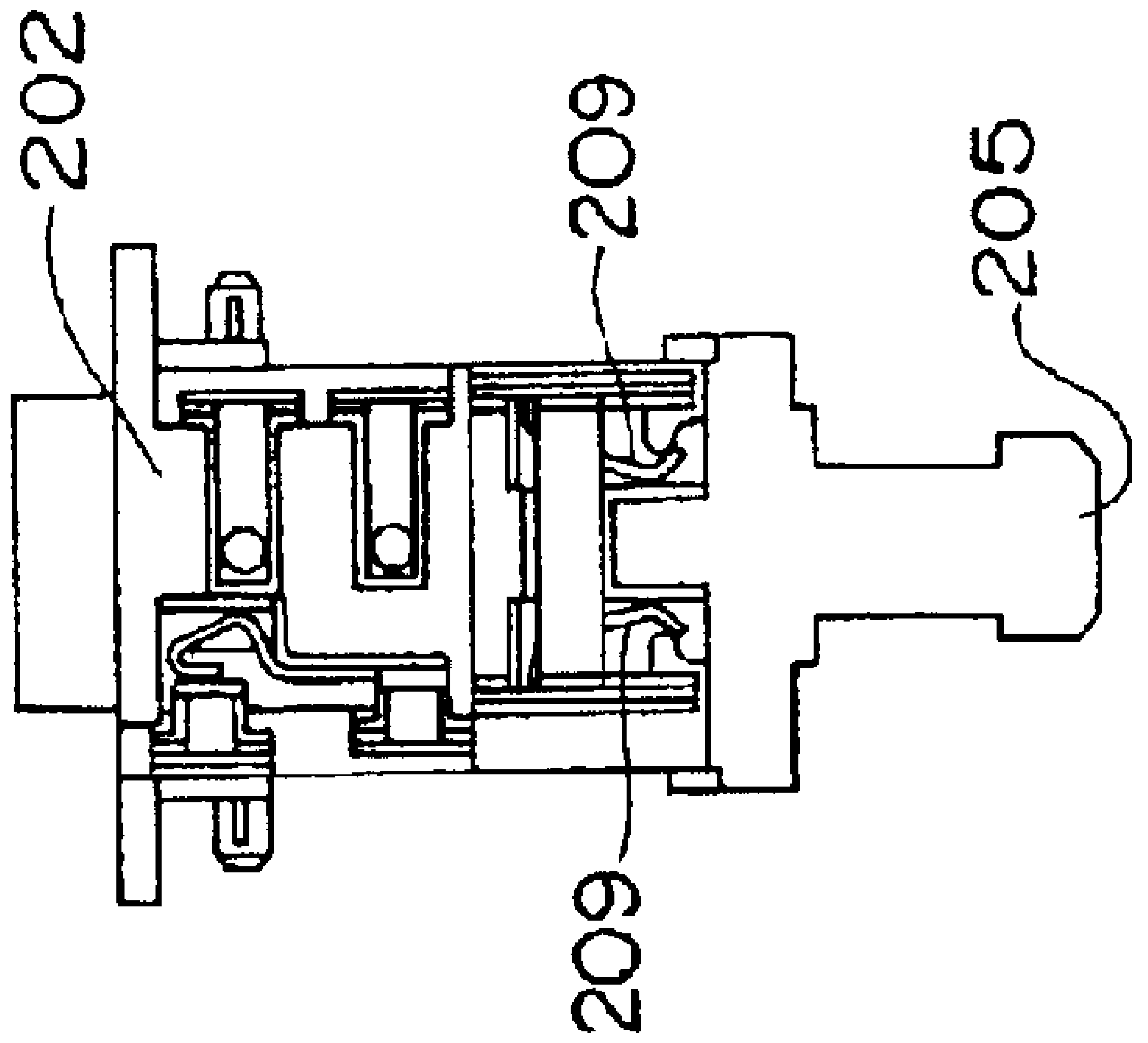

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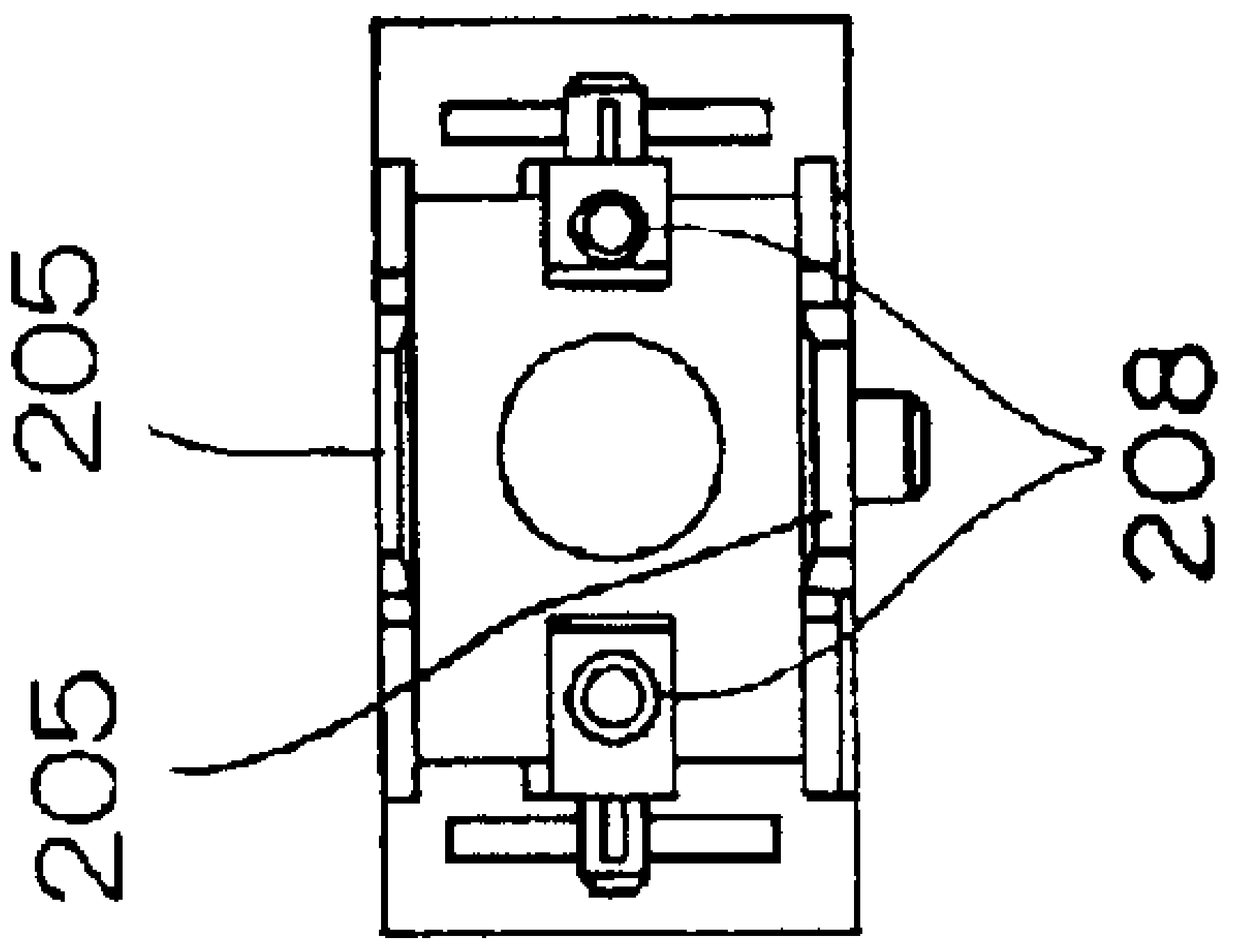

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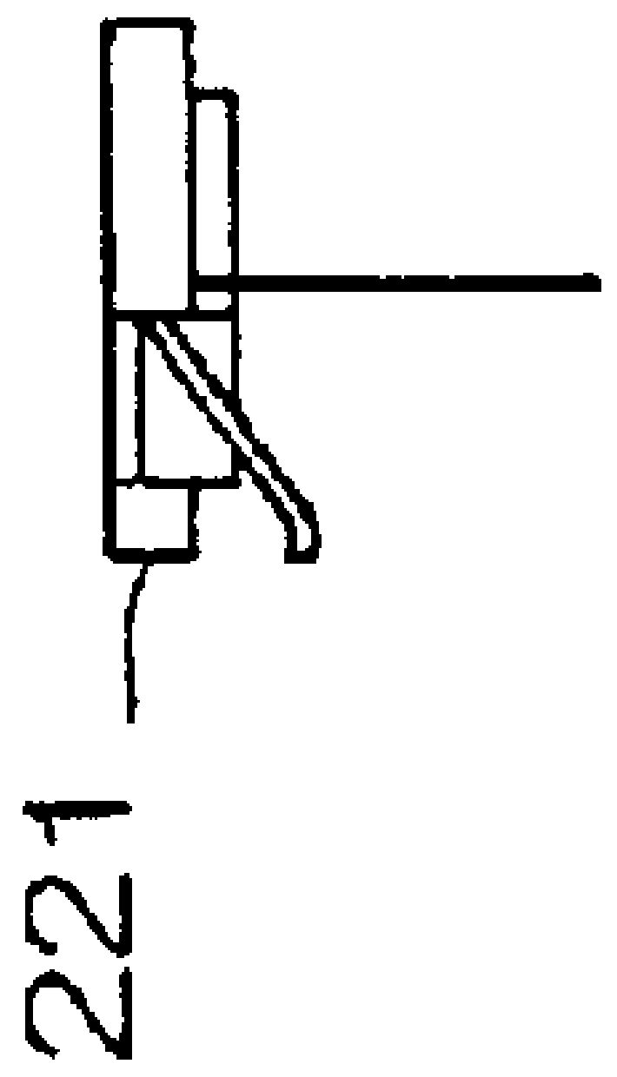

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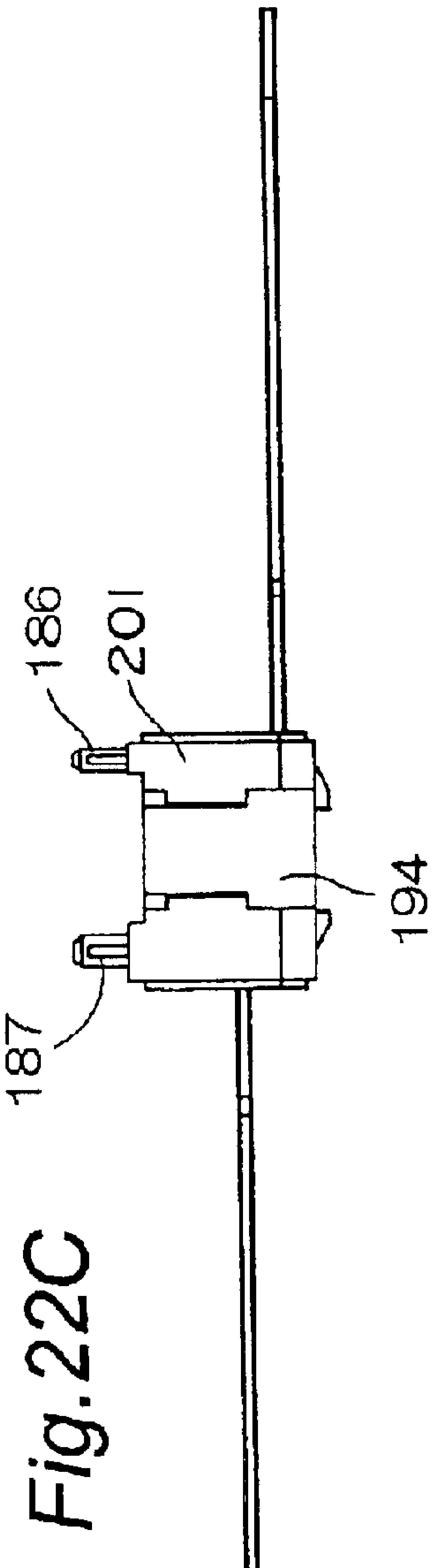


Fig.22C

Fig. 23

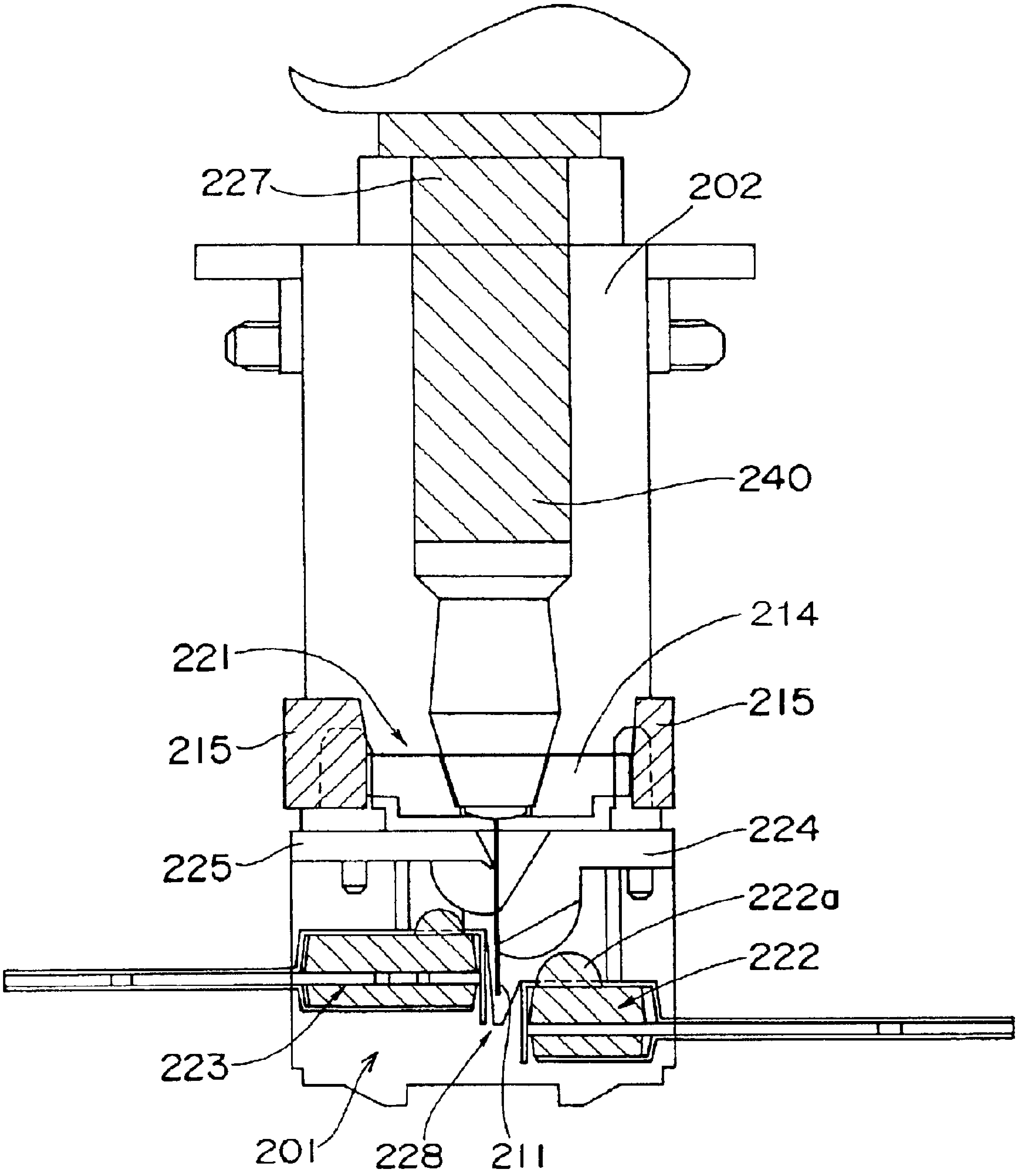


Fig.24

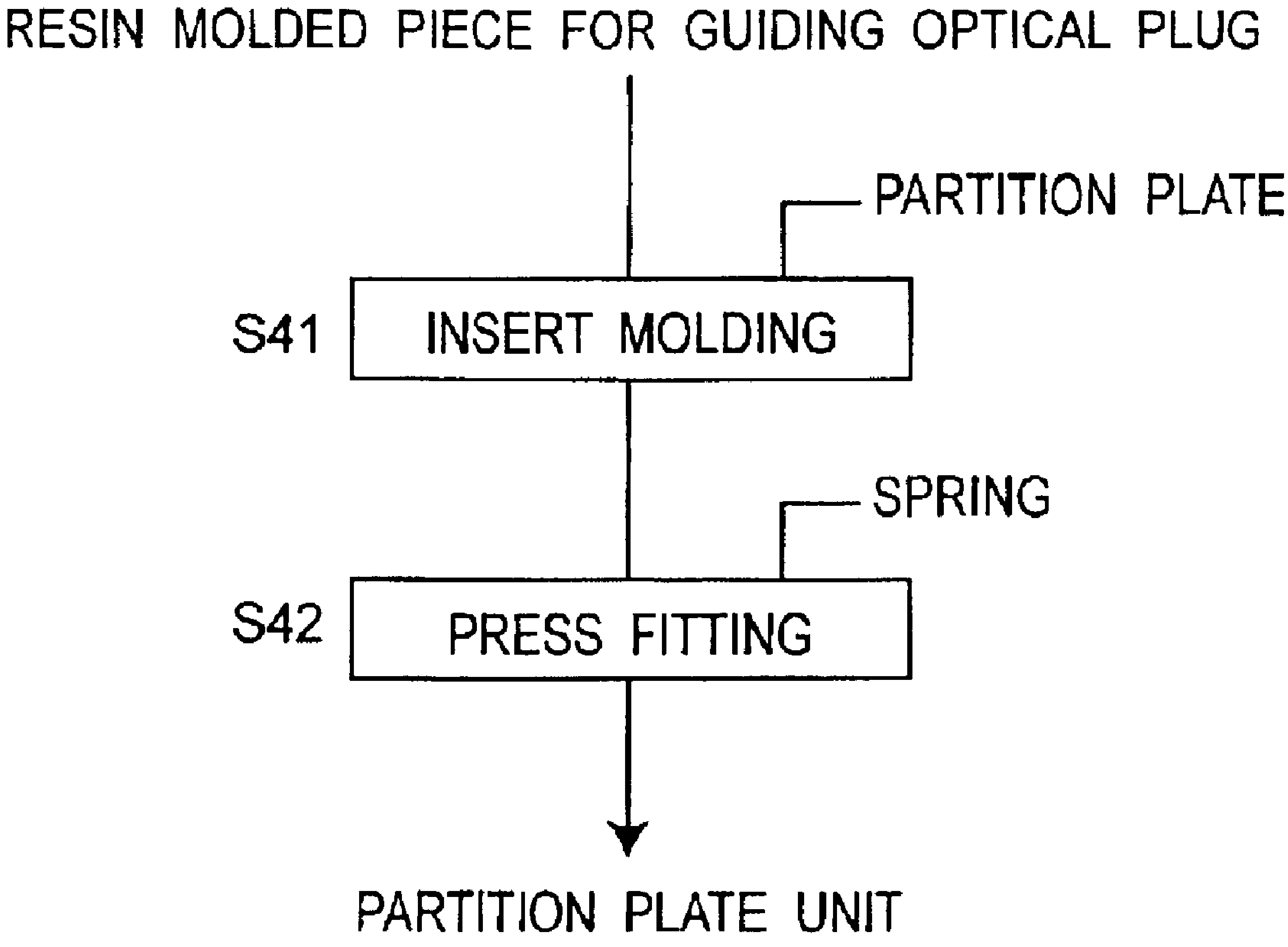

RESIN MOLDED PIECE FOR GUIDING OPTICAL PLUG
PARTITION PLATE
S41
INSERT MOLDING
SPRING
S42
PRESS FITTING
PARTITION PLATE UNIT

Fig. 25

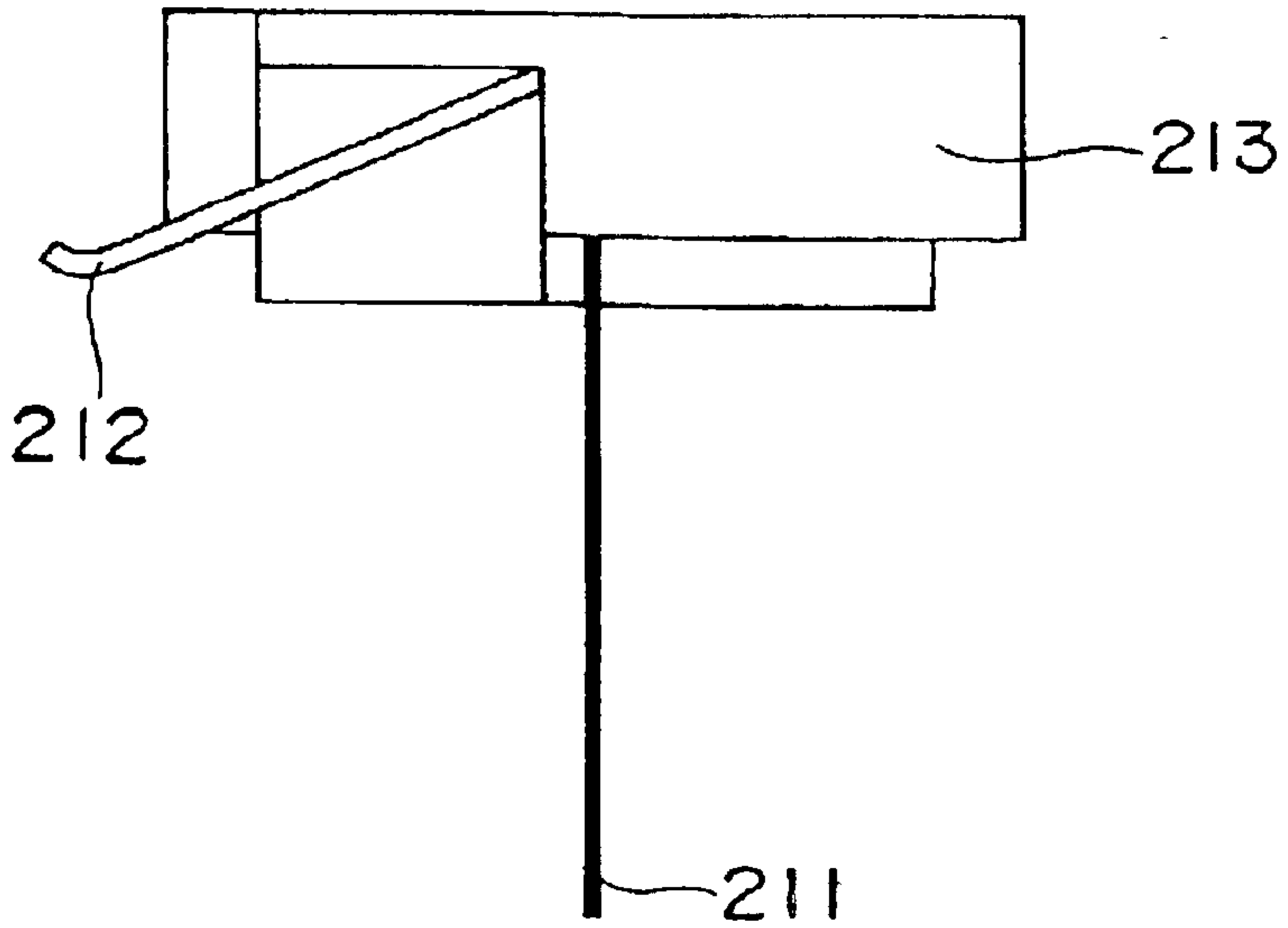
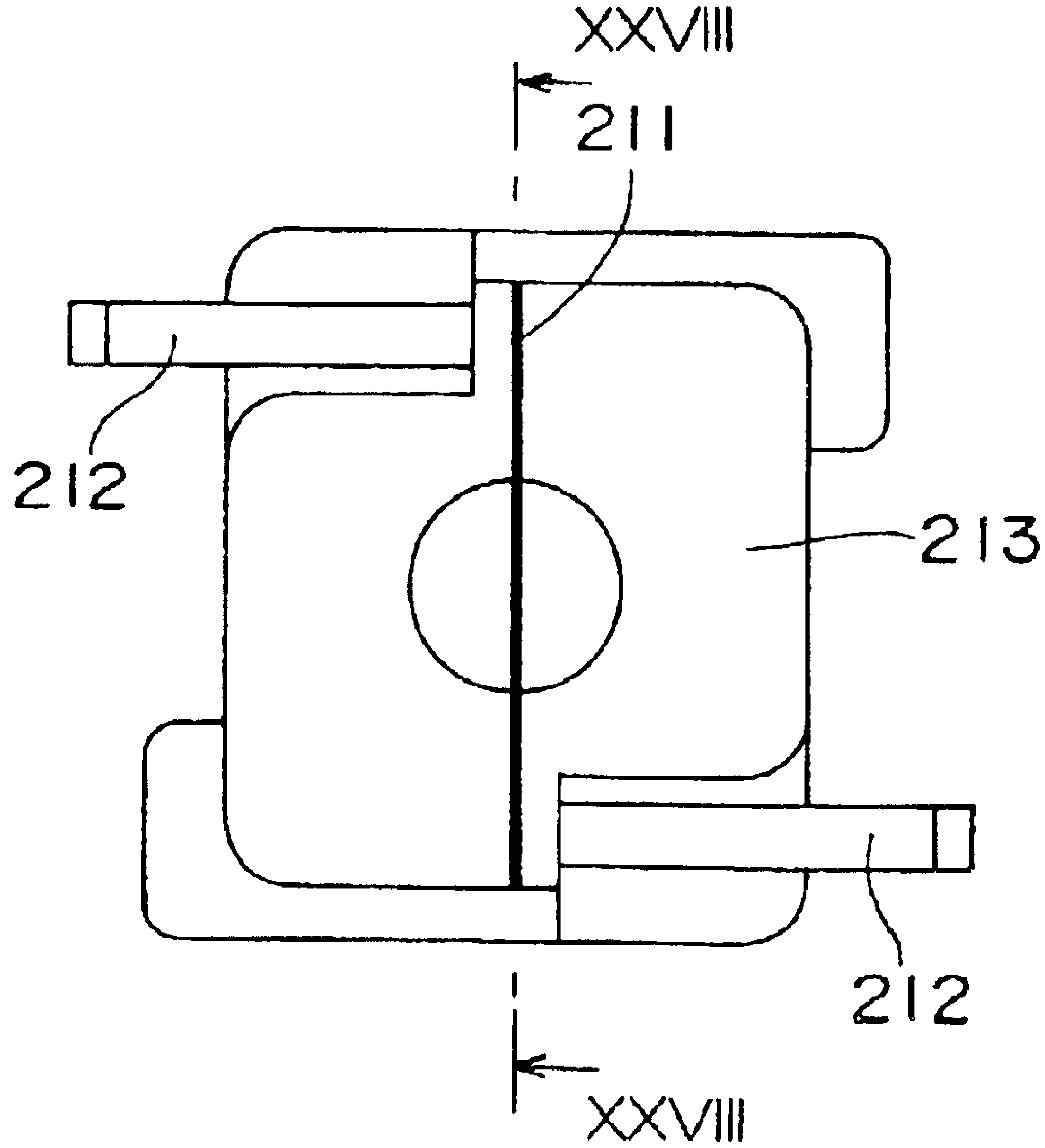


Fig. 26



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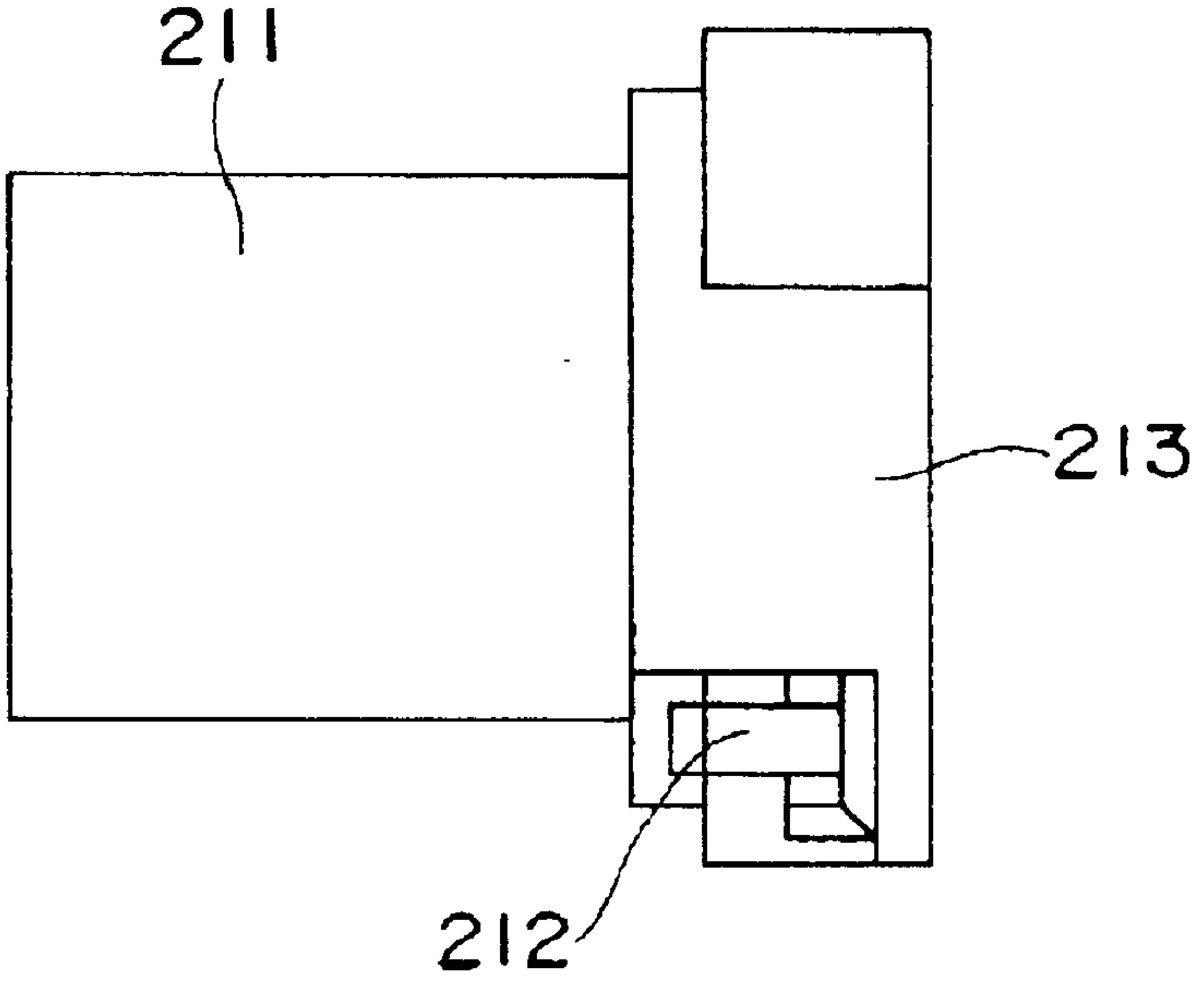

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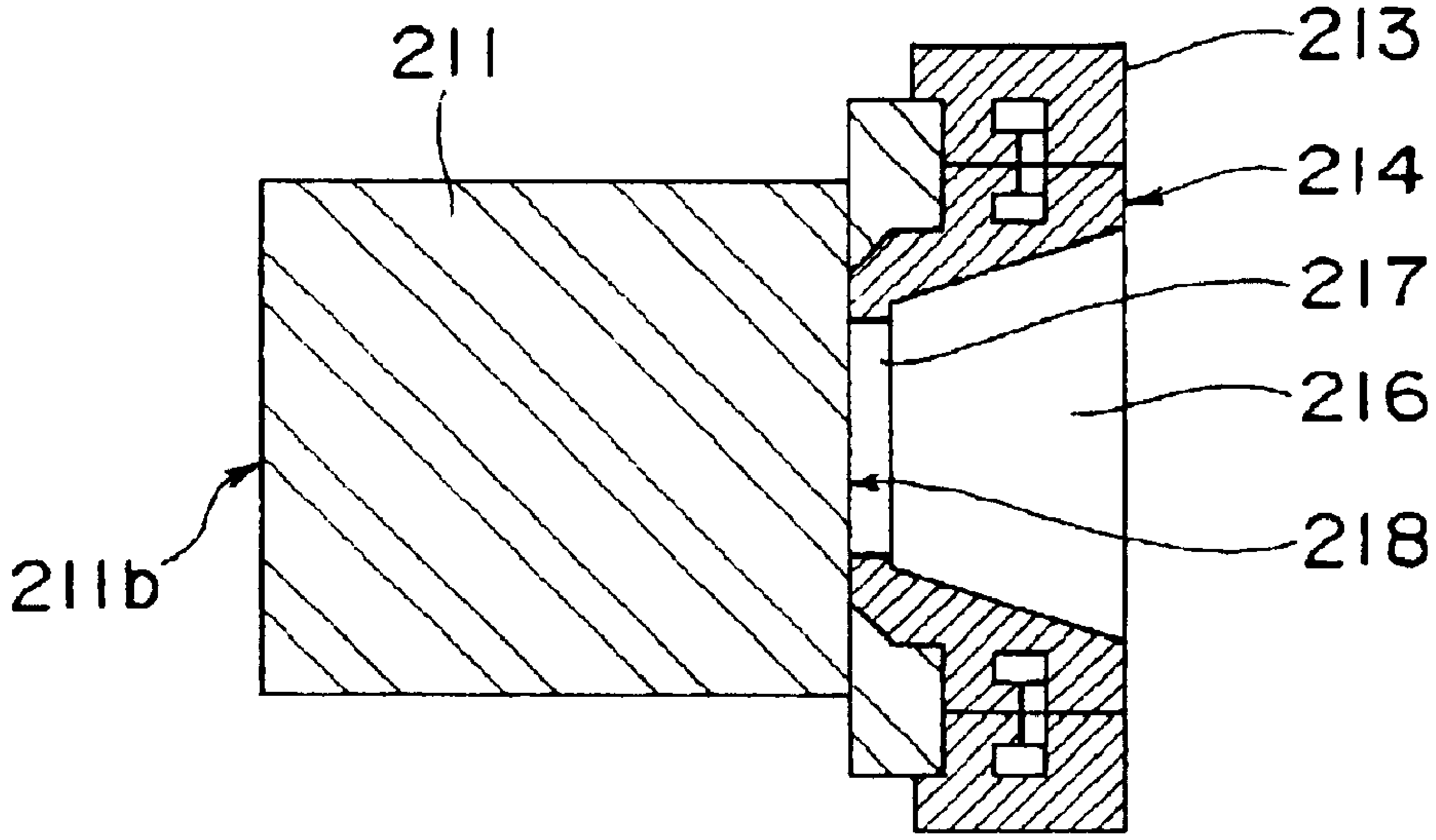

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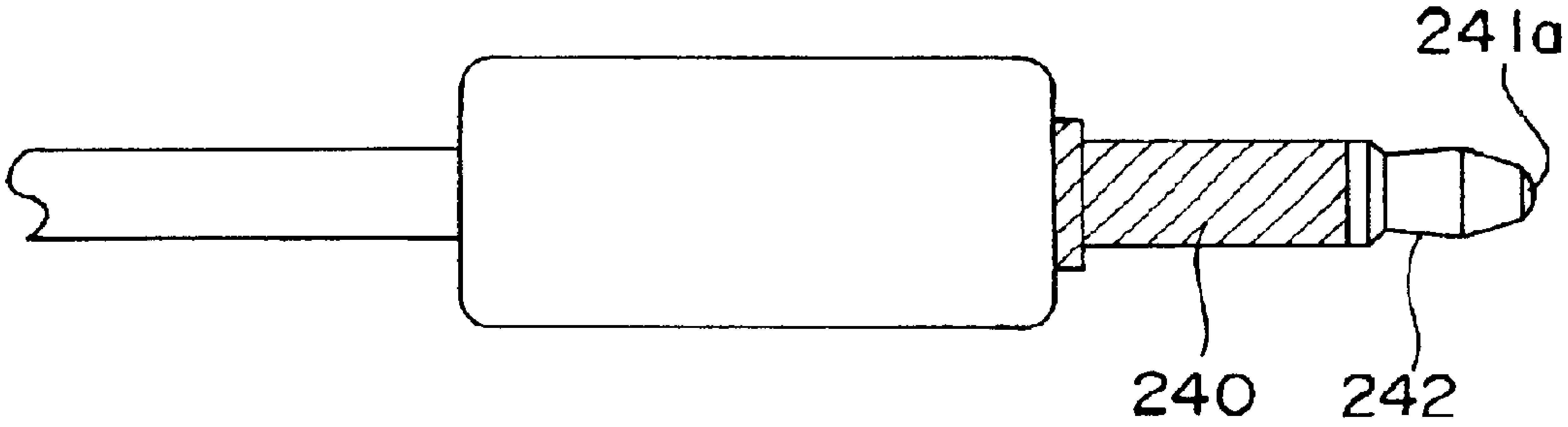

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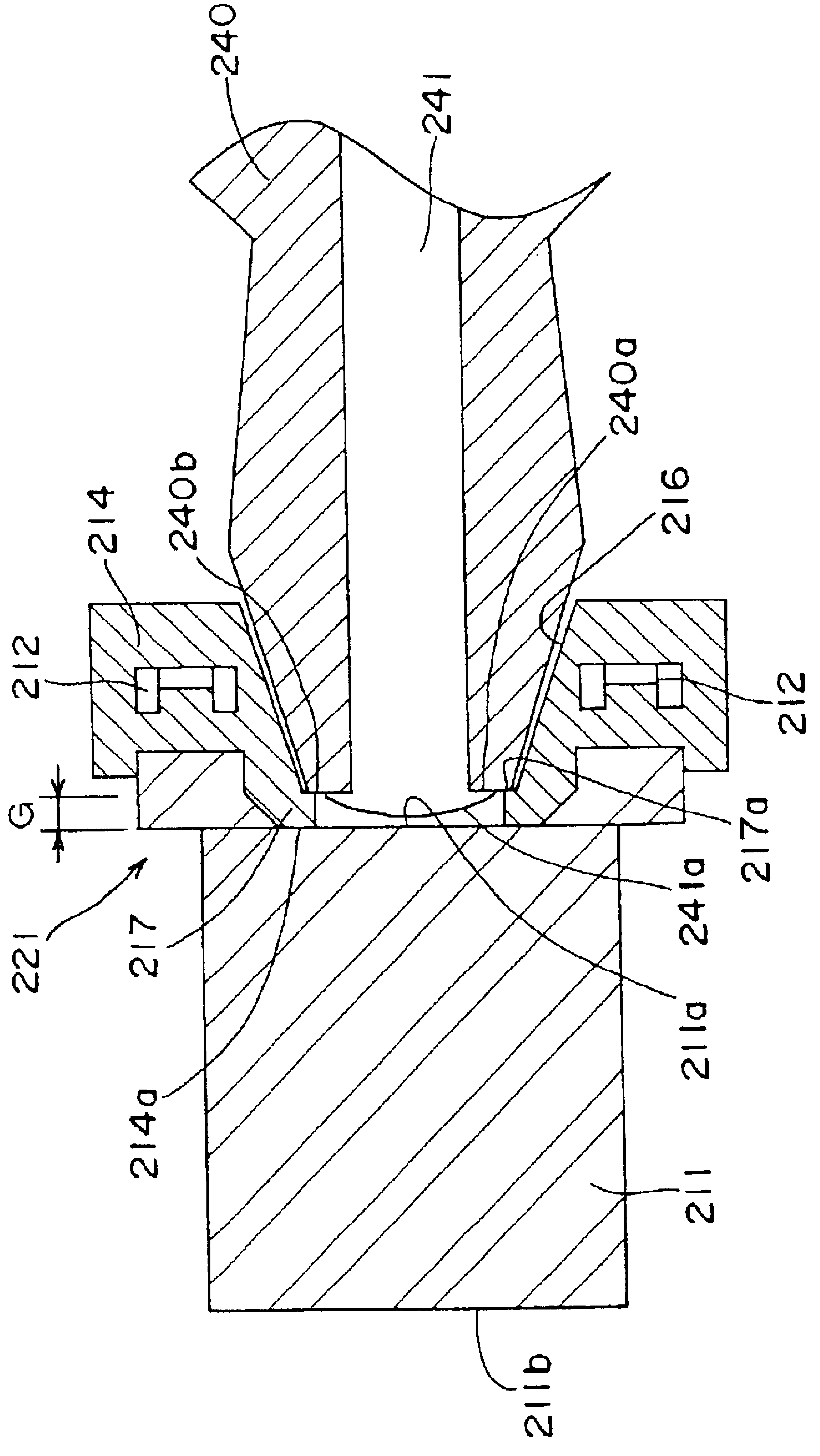
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Fig.31

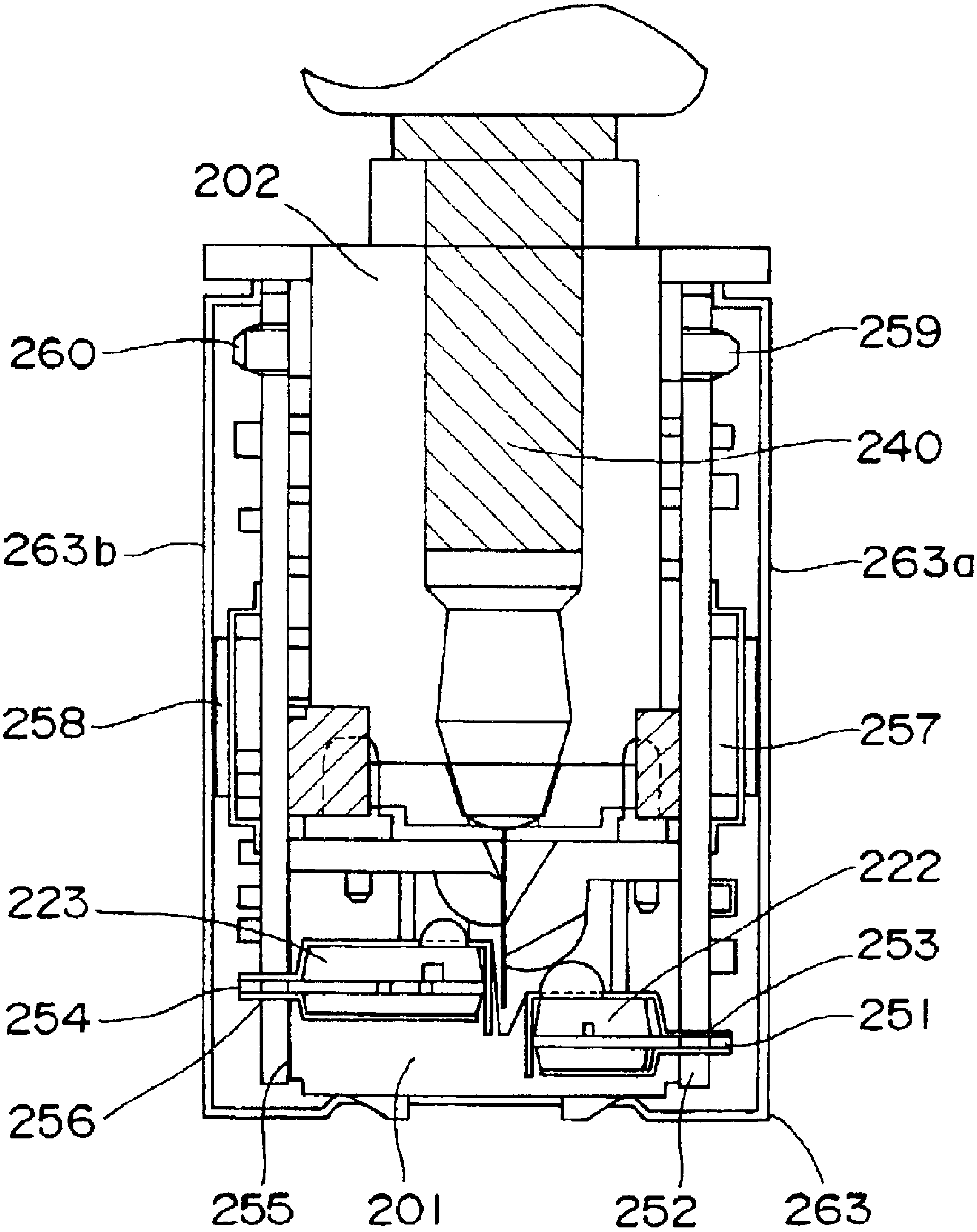
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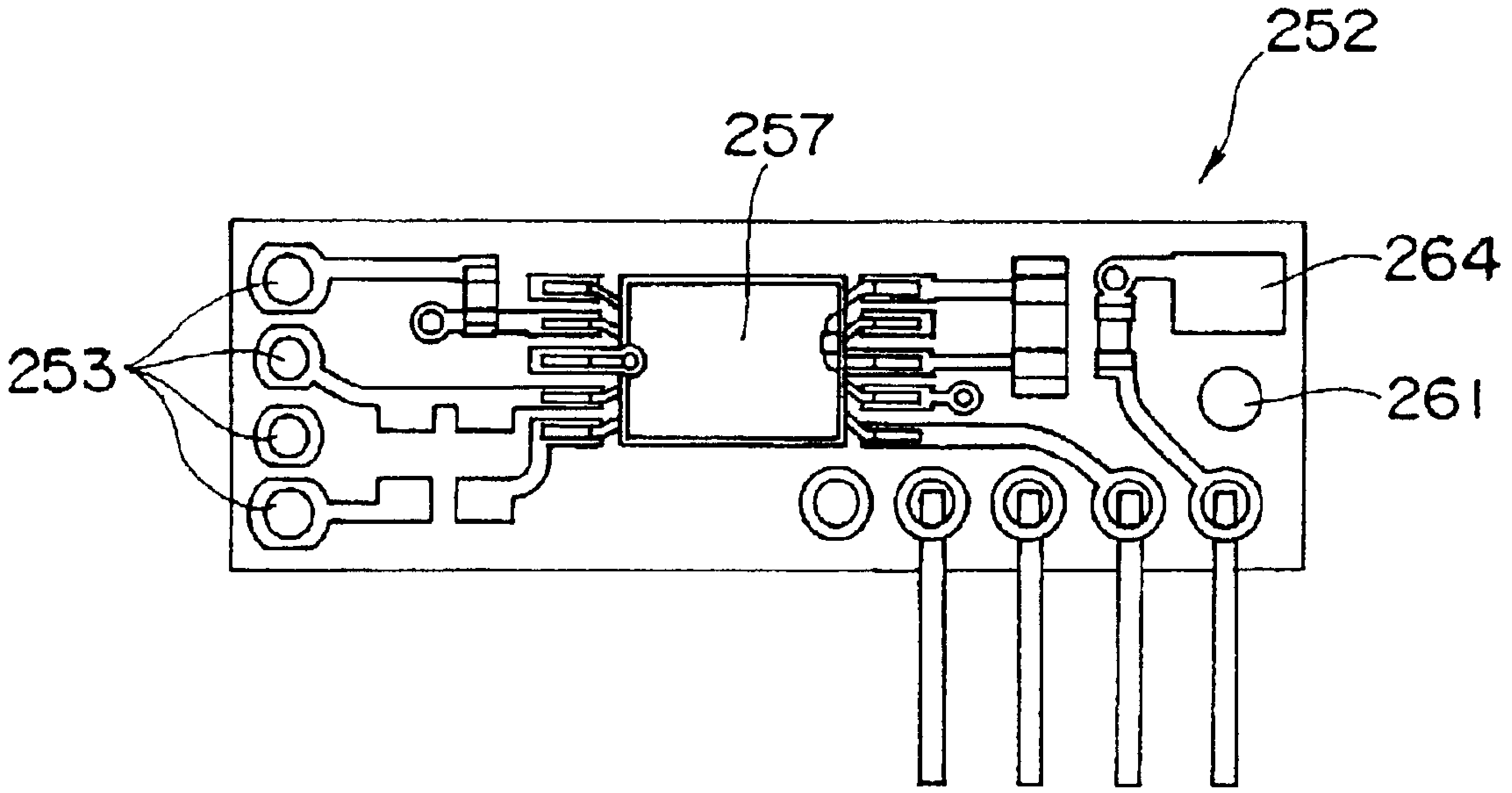
Fig.32A



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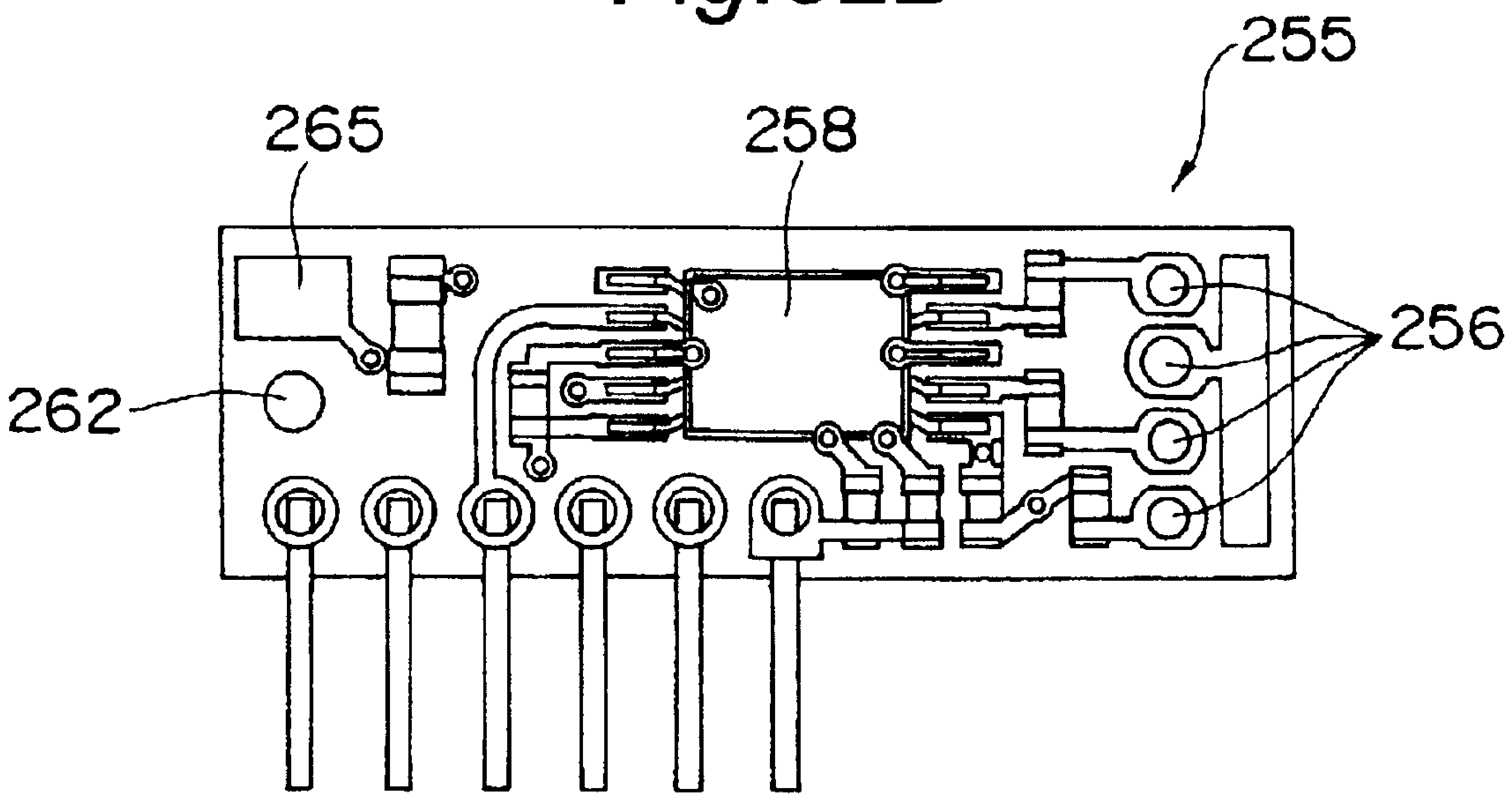
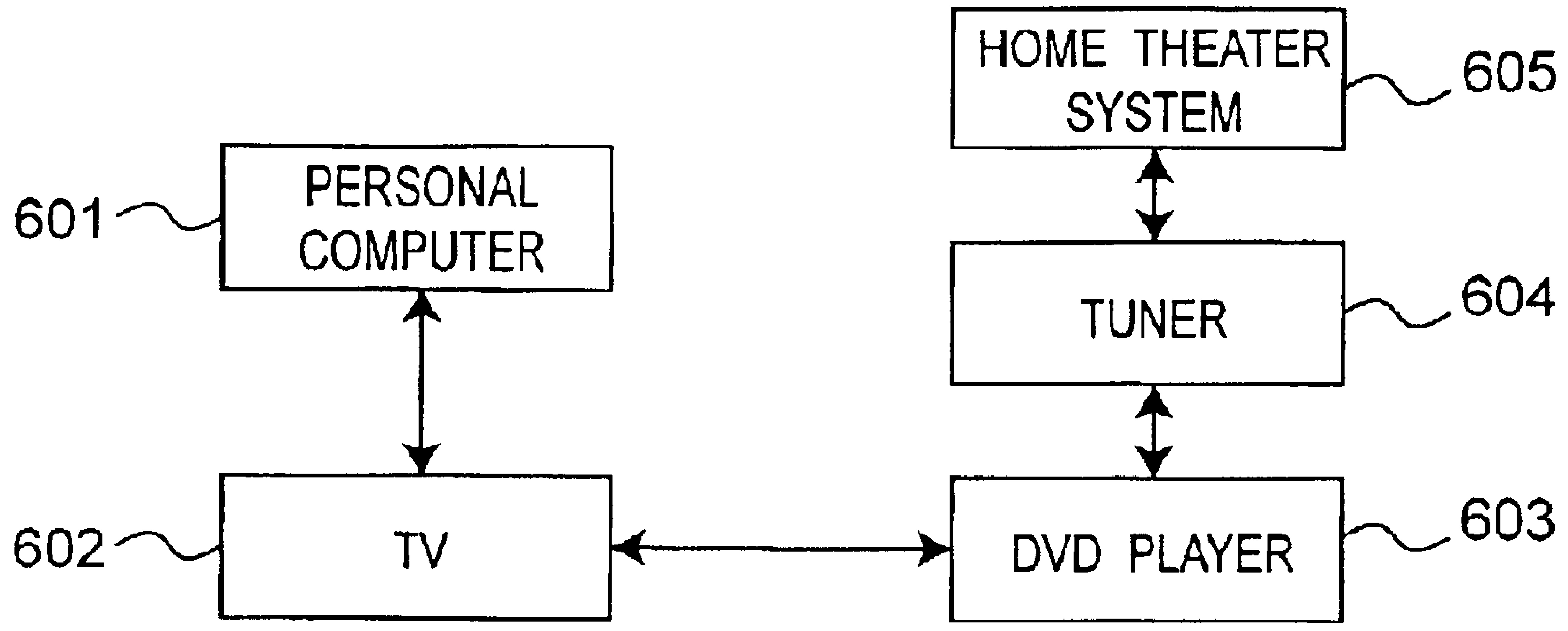
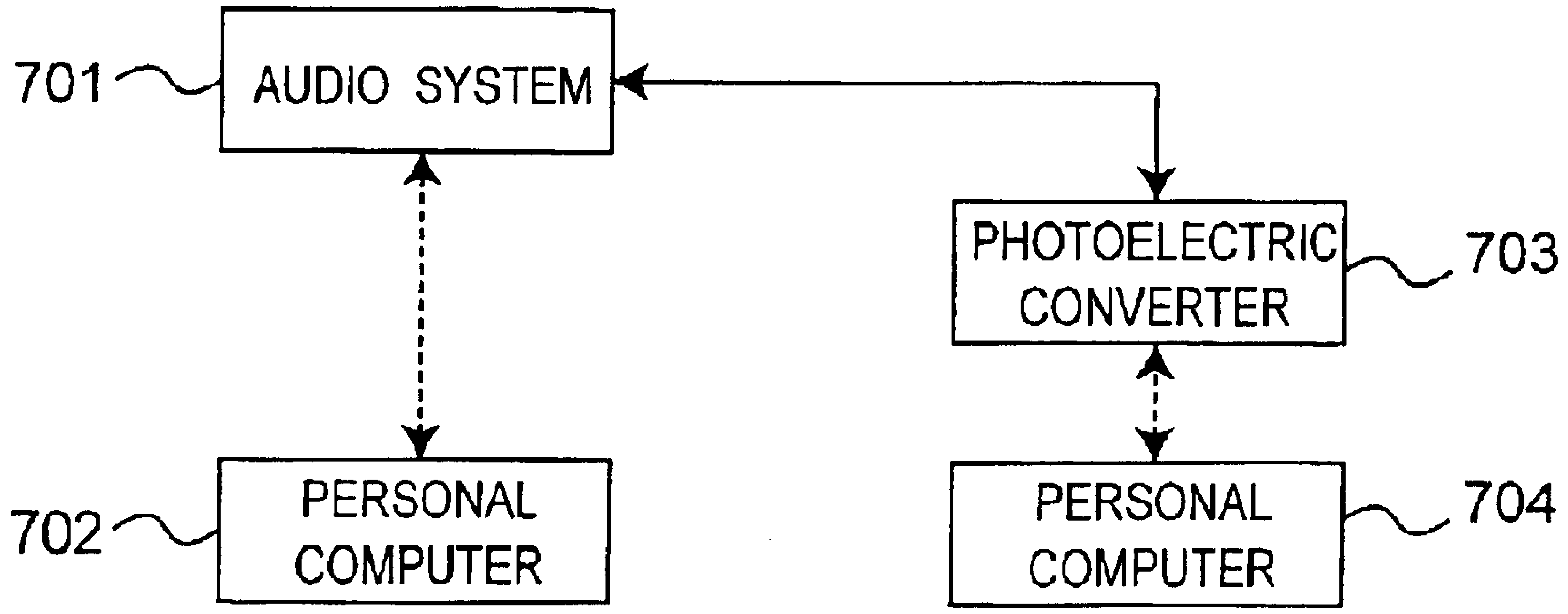


Fig. 33



HOME THEATER SYSTEM
605
PERSONAL COMPUTER
601
TUNER
604
602
TV
DVD PLAYER
603

Fig. 34



701
AUDIO SYSTEM
PHOTOELECTRIC CONVERTER
703
702
PERSONAL COMPUTER
PERSONAL COMPUTER
704

Fig.35A

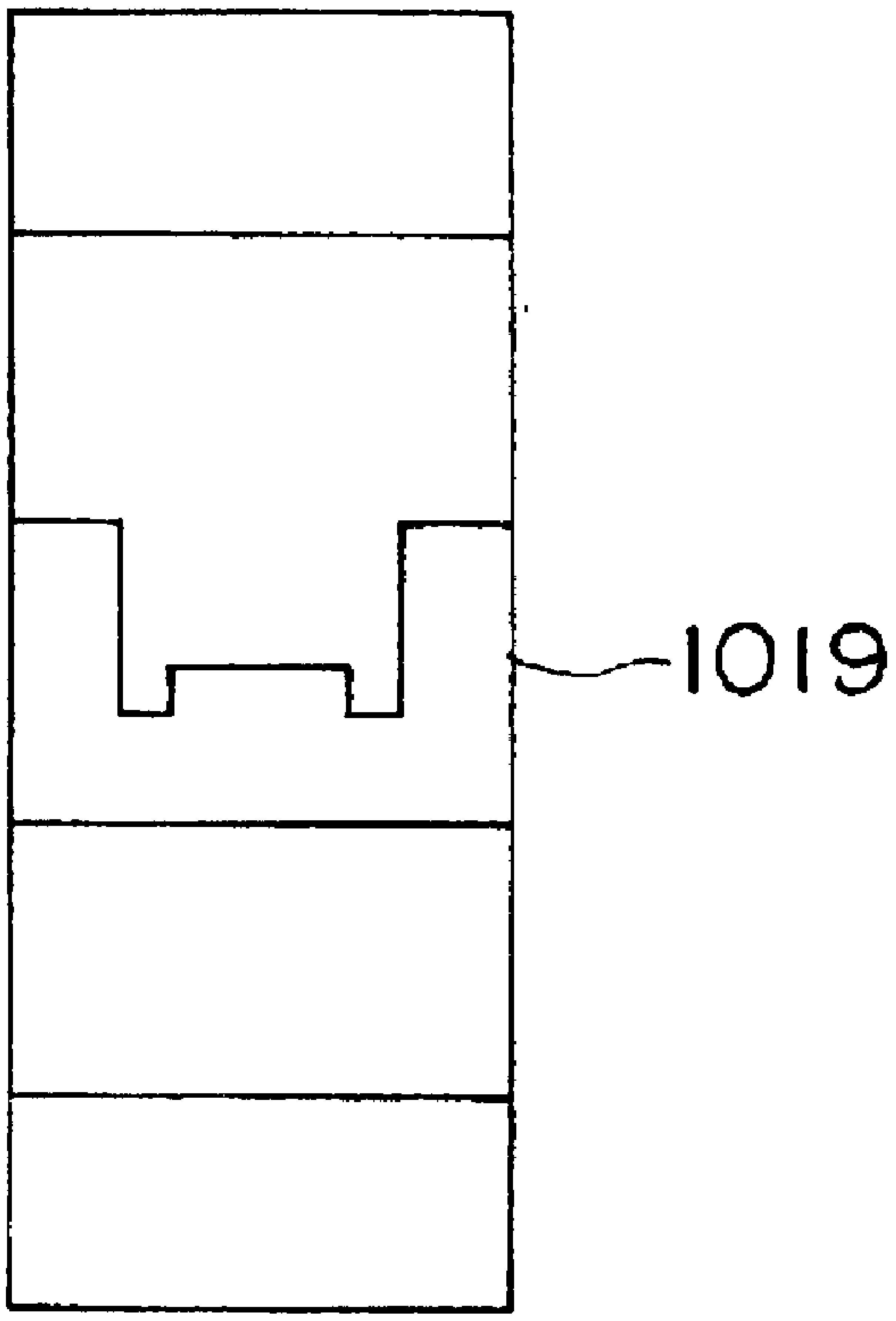


Fig.35B

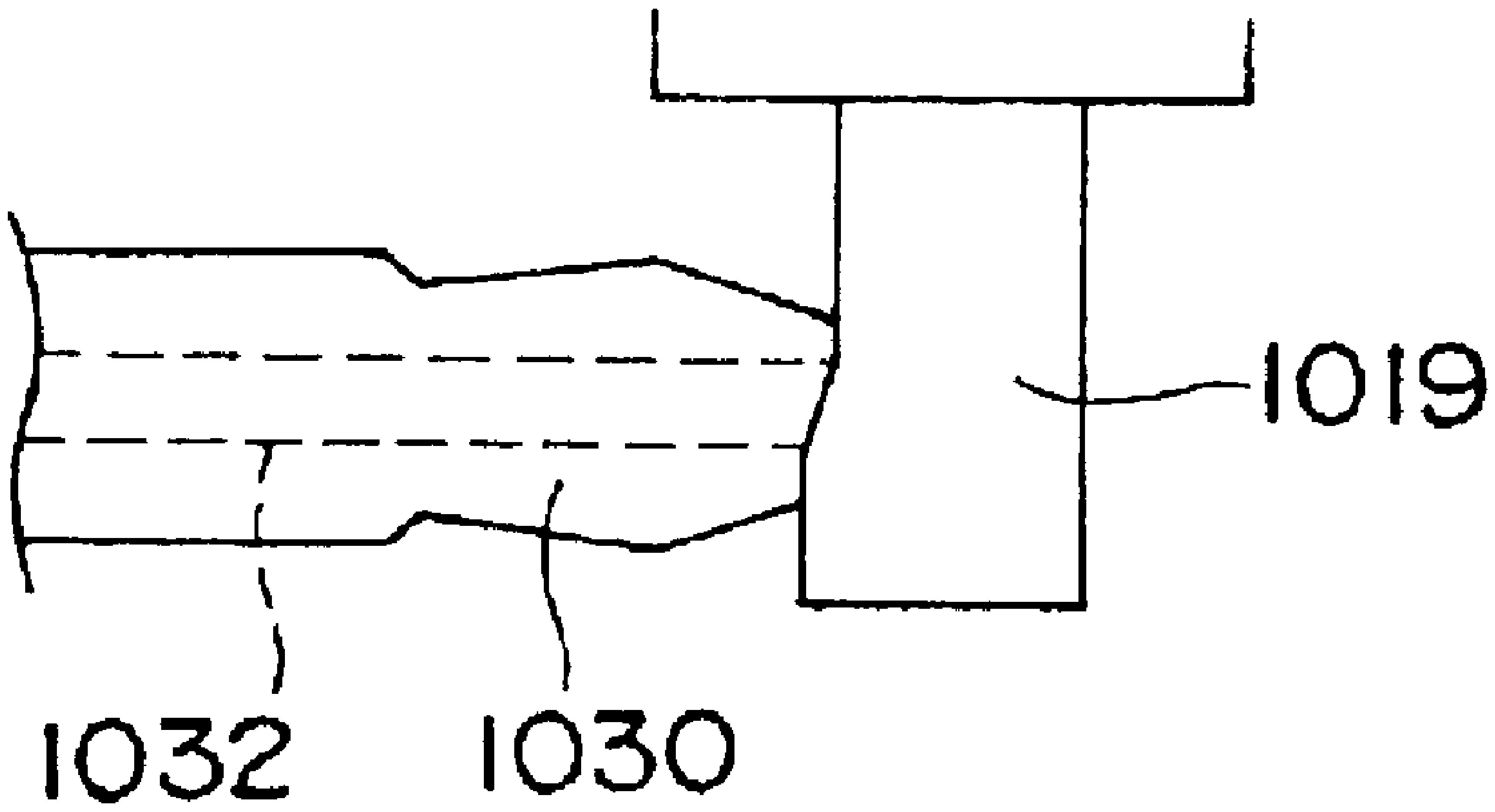


Fig.36A

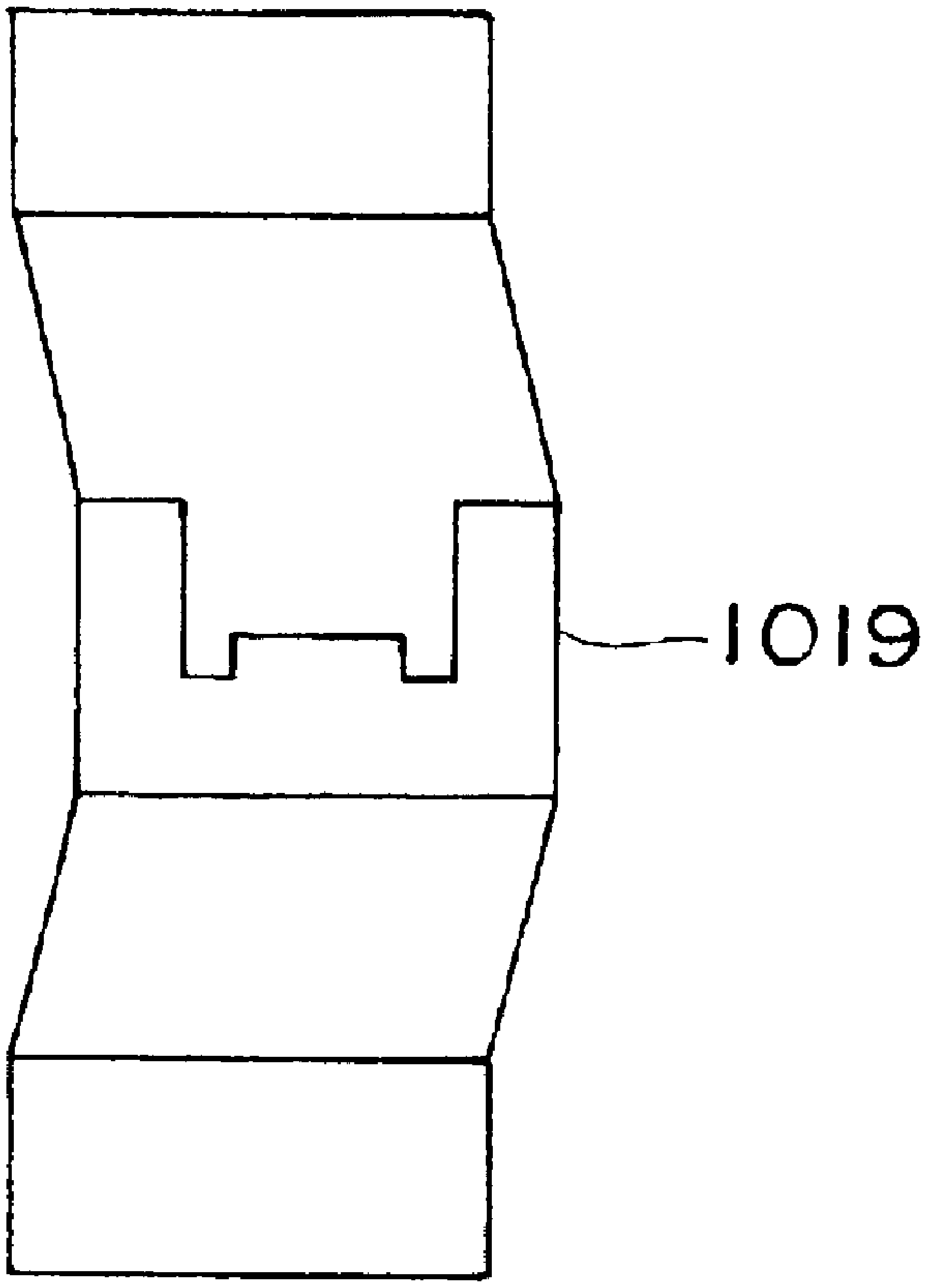


Fig.36B

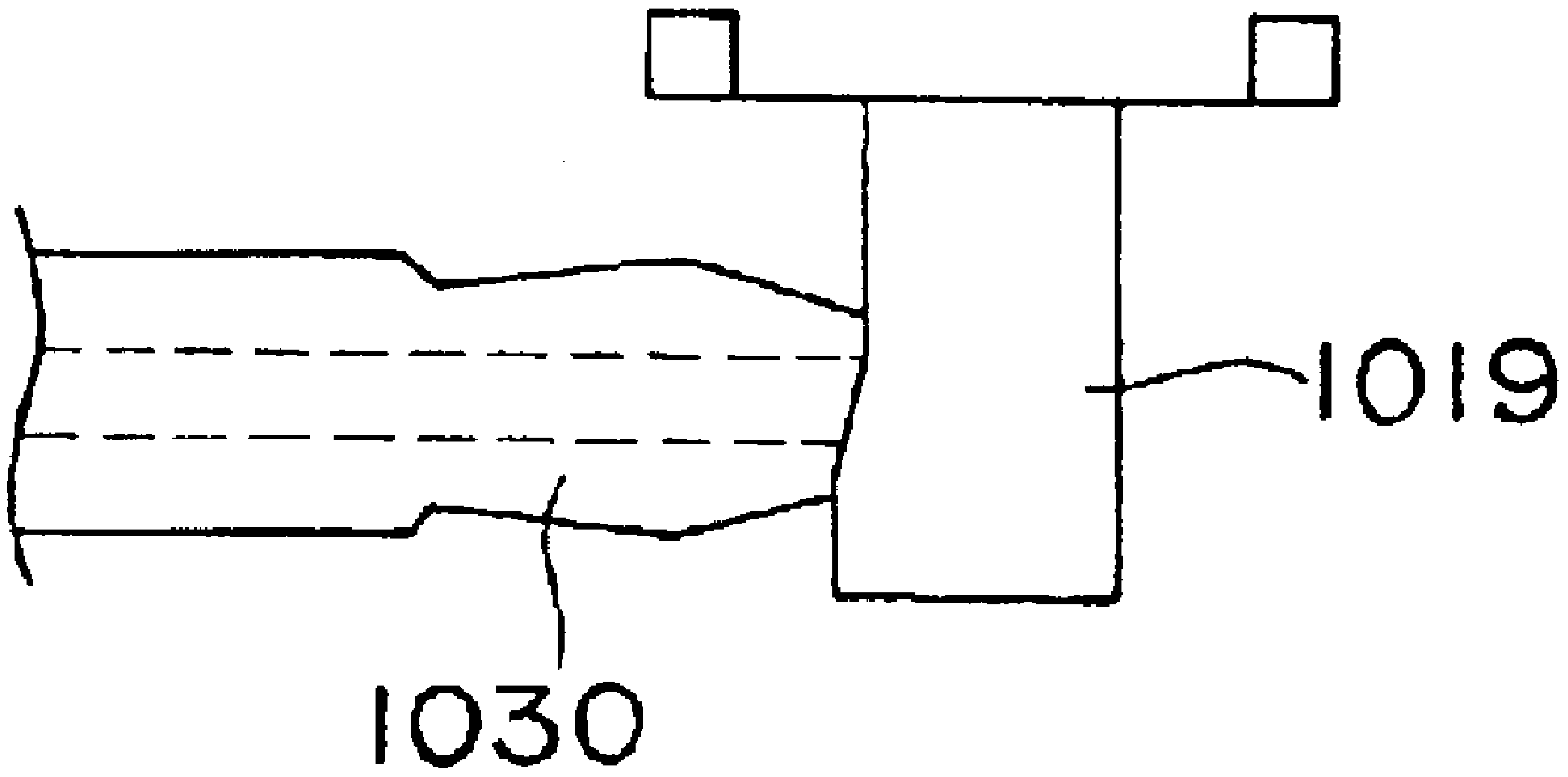


Fig.37A

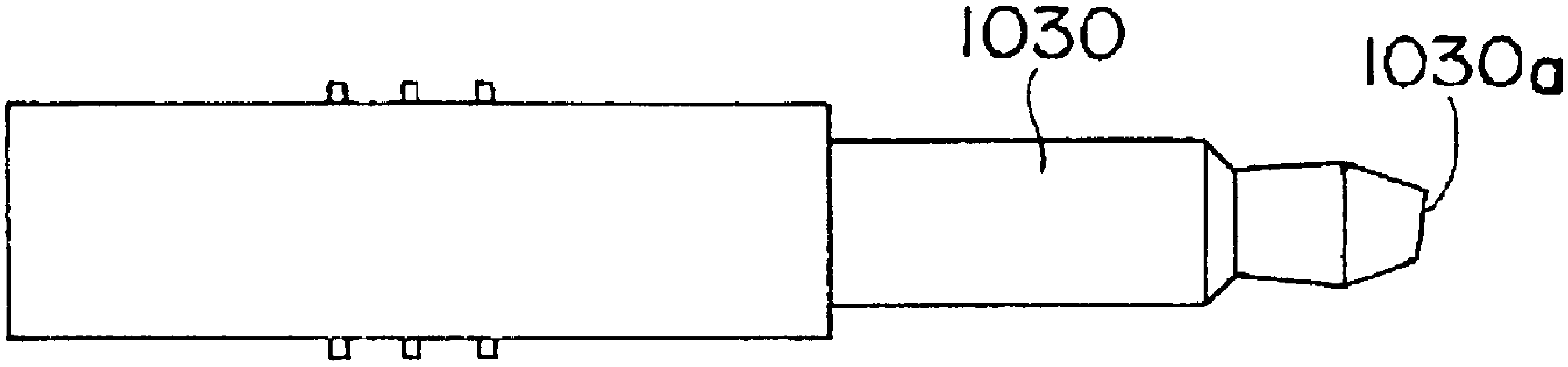


Fig.37B

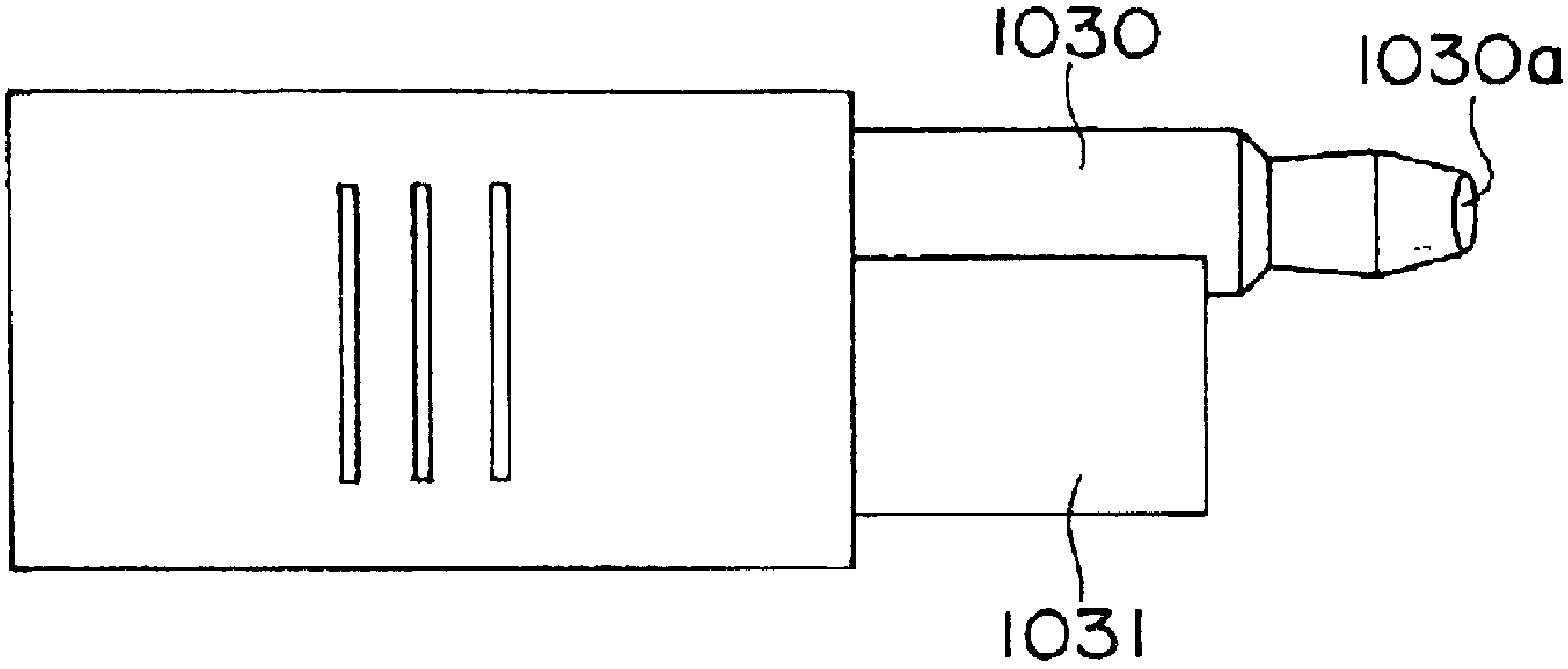
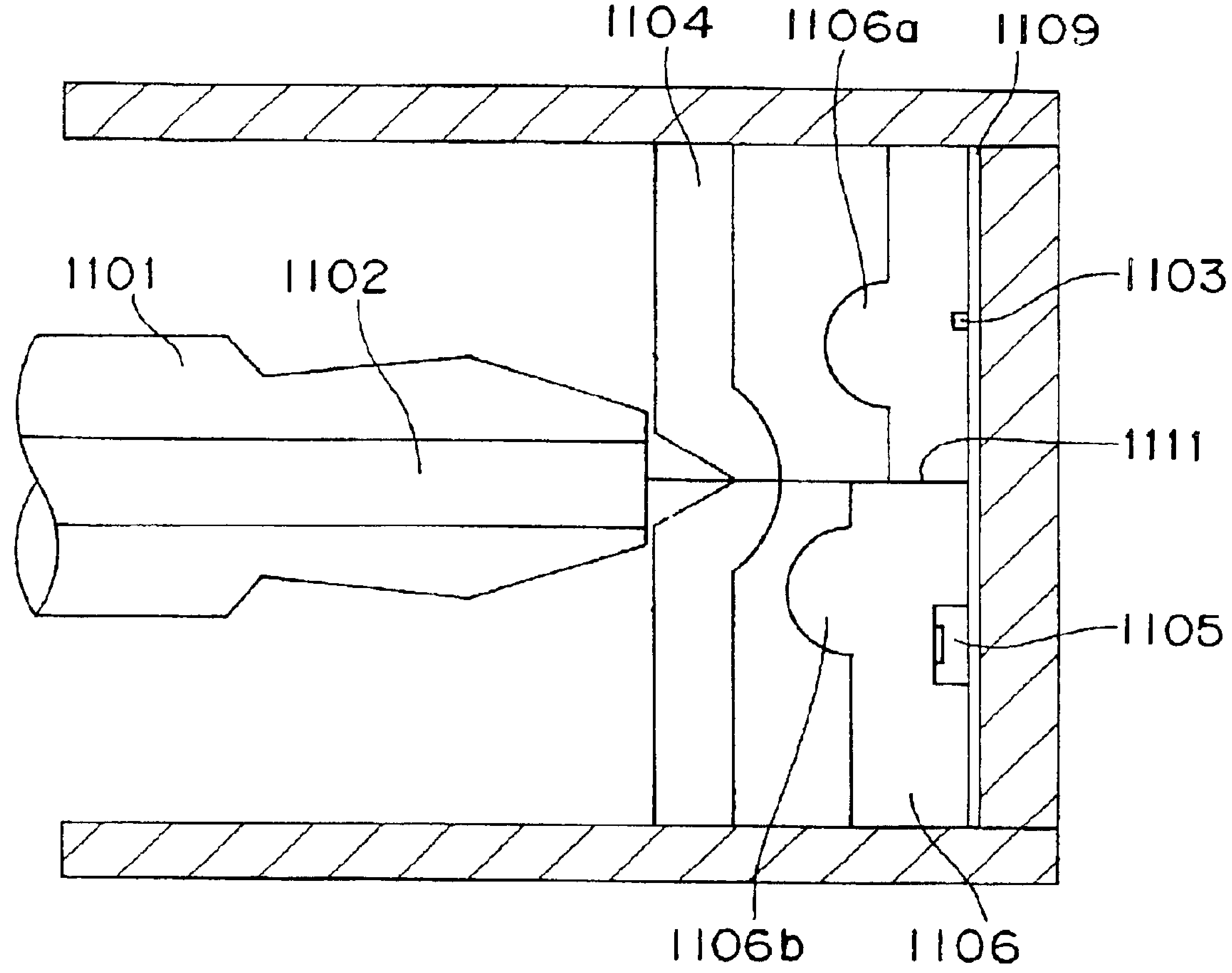


Fig.38 PRIOR ART



OPTICAL TRANSMITTER-RECEIVER MODULE, METHOD OF MANUFACTURING THE MODULE, AND ELECTRONIC DEVICE USING THE MODULE

BACKGROUND OF THE INVENTION

The present invention relates to an optical transmitter-receiver module and an electronic device for use in a single-core bidirectional optical transmitter-receiver system capable of performing transmission and reception with a single-core optical fiber. The present invention relates, in particular, to a digital communication system, which is able to perform high-speed transmission, such as IEEE1394 (Institute of Electrical and Electronic Engineers 1394) and USB (Universal Serial Bus) 2.0. The present invention also relates to a method of manufacturing the optical transmitter-receiver module.

Conventionally, as a first optical transmitter-receiver module, there is a one as described in Japanese Patent Laid-Open Publication No. 2001-116961. In this optical transmitter-receiver module, full-duplex communications are achieved by reducing electric crosstalk by employing a shield plate while reducing optical crosstalk by employing a light-tight partition plate that abuts against the end surface of the optical fiber so as to separate the light-emitting device and the light-receiving device from each other.

FIG. **35**A and FIG. **36**A are plan views of a partition plate **1019**, while FIG. **35**B and FIG. **36**B are side views showing the positional relationship of the partition plate **1019** with respect to an optical plug **1030**. With regard to this first optical transmitter-receiver module, FIGS. **35**A and **35**B shows a state in which the optical plug **1030** provided internally with a single-core optical fiber **1032** is partway inserted in an optical transmitter-receiver module (overall view is not shown) and starts coming in contact with the partition plate **1019**. FIGS. **36**A and **36**B show a state in which the optical plug **1030** is completely inserted in the optical transmitter-receiver module and fully put in contact with the partition plate **1019**.

FIG. **37**A shows a side view of an essential part of an optical cable, which has the plug **1030** and constitutes an optical transmitter-receiver system with the aforementioned optical transmitter-receiver module, while FIG. **37**B shows a rear view of the optical cable that has the optical plug **1030**. As shown in FIGS. **37**A and **37**B, the optical plug **1030** (including the optical fiber) is provided at each end portion (only one end portion is shown) of the optical cable, and a front end of the optical plug **1030**, which includes a tip of the optical fiber, has an inclined surface **1030***a* inclined forward in the lengthwise direction of the optical fiber (i.e., toward the other optical transmitter-receiver module side not shown). Moreover, the optical plug **1030** is provided with a anti-rotation key **1031** extended in the horizontal direction, and the optical transmitter-receiver module is internally provided with a keyway (not shown) that cooperates with the key **1031**, for preventing possible changes in the optical input and characteristics in accordance with the rotation of the optical plug **1030**.

Moreover, as a second conventional optical transmitter-receiver module, there is a one as described in Japanese Patent Laid-Open Publication No. 2001-147349. As shown in FIG. **38**, this second optical transmitter-receiver module employs a partition plate **1111** similar to that of the aforementioned first conventional optical transmitter-receiver module that has an optical system employing a Foucault prism **1104**. According to this, in the second optical transmitter-receiver module, the end surface of the optical fiber **1102** of the optical plug **1101** abuts against the partition plate **1111**, and a light-emitting element **1103** and a light-receiving element **1105** are molded or encapsulated with a molding resin **1106**. Lens portions **1106***a* and **1106***b* are integrally formed in the plastic molding stage of the molding resin.

In the aforementioned first conventional optical transmitter-receiver module, the optical plug **1030** has the anti-rotation key **1031**. Therefore, the optical plug **1030** cannot be inserted into the optical transmitter-receiver module unless the key **1031** is aligned with the keyway of the optical transmitter-receiver module when fitting the optical plug **1030**, and this disadvantageously causes inconvenience to the user. However, if the anti-rotation key **1031** of the optical plug **1030** is removed to improve the convenience at the time of insertion of the optical plug, then the optical plug **1030** becomes rotatable. Therefore, if the optical plug **1030** rotates with an optical fiber end surface **1030***a* being in contact with the partition plate **1019**, then there occurs a problem that the inclined end surface **1030***a* of the optical fiber and/or the partition plate **1019** is damaged.

Moreover, the second conventional optical transmitter-receiver module, which employs the Foucault prism optical system having the partition plate **1111** similar to that of the first conventional optical transmitter-receiver module, has the structure in which the partition plate **1111** abuts against the end surface of the optical fiber **1102**. Therefore, similarly to the first conventional optical transmitter-receiver module, there occurs a problem that the end surface of the optical fiber **1102** and/or the partition plate **1111** is damaged. Furthermore, the light-emitting element **1103** and the light-receiving element **1105** are mounted on an identical substrate **1109** in this second optical transmitter-receiver module, but the optical positions of the light-emitting element **1103** and the light-receiving element **1105** are not optimized with regard to the optical system that has the partition plate **1111**.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to provide an optical transmitter-receiver module and an electronic device using the same, which module is able to perform high-quality optical transmission by full-duplex communication scheme by using a light-tight partition plate and able to prevent the optical fiber end surface and the partition plate from being damaged even if the inserted optical plug is rotated in the module.

Another object of the present invention is to provide a method of easily manufacturing such modules.

In order to accomplish the above object, the present invention provides an optical transmitter-receiver module having a light-emitting element for emitting transmission signal light and a light-receiving element for receiving reception signal light, said module being able to perform both transmission of the transmission signal light and reception of the reception signal light by means of a single-core optical fiber, said module comprising:

a jack section for detachably holding an optical plug provided at an end portion of the optical fiber;

a light emitting/receiving unit having the light-emitting element and light-receiving element positioned and fixed in place and molded in one piece; and

a light-tight partition plate unit for separating an optical path of the transmission signal light and an optical path of the reception signal light from each other, said light-tight partition plate being arranged so as to be held between the jack section and the light emitting/receiving unit.

According to the optical transmitter-receiver module of the above construction, by arranging the light-tight partition plate unit for separation between the optical path of the transmission signal light and the optical path of the reception signal light so that the plate is held between the jack section and the light emitting/receiving unit, the coupling of the transmission signal light directly with the light-receiving element is restrained, so that high-quality optical transmission by the full-duplex communication method is achieved. Also, the optical fiber end surface and the partition plate are prevented from being damaged even if the inserted optical plug is rotated in the module.

In one embodiment, the optical transmitter-receiver module has a positioning means having a projection provided at one of the jack section and the light emitting/receiving unit and a hole provided at the other of the jack section and the light emitting/receiving unit, and positioning the light emitting/receiving unit by press-fitting the projection into the hole.

According to this embodiment, by press-fitting the projection provided at one of the jack section and the light emitting/receiving unit into the hole provided at the other of the jack section and the light emitting/receiving unit, the positioning accuracy of the light emitting/receiving unit can easily be improved.

In one embodiment, the optical transmitter-receiver module has an anti-detachment means having a hook provided at one of the jack section and the light emitting/receiving unit and a groove provided at the other of the jack section and the light emitting/receiving unit to prevent detachment of the light emitting/receiving unit by fitting the hook in the groove.

According to this embodiment, by fitting the hook provided at one of the jack section and the light emitting/receiving unit to the groove provided at the other of the jack section and the light emitting/receiving unit, the positioning accuracy of the light emitting/receiving unit can be improved, and the light emitting/receiving unit can easily be prevented from detaching from the jack section.

In one embodiment, the module has a light-emitting element drive circuit board for driving the light-emitting element, and a light-receiving element processing circuit board for processing the reception signal of the light-receiving element. The light-emitting element drive circuit board and the light-receiving element processing circuit board are arranged with the jack section and the light emitting/receiving unit interposed therebetween.

With this arrangement, the distance between both the circuit boards can be made large, and this enables the electromagnetic isolation of both the circuit boards, whereby an optical transmitter-receiver module having a high signal-to-noise ratio is achievable.

In one embodiment, the optical transmitter-receiver module has a board positioning means having a first hole provided in the light-emitting element drive circuit board at one of opposite end portions thereof, a projection provided at the jack section, and a second hole provided in the light-emitting element drive circuit board at the other of the opposite end portions thereof, and positioning the light-emitting element drive circuit board by press-fitting the projection of the jack section into the first hole of the light-emitting element drive circuit board and connectively inserting a terminal of the light emitting/receiving unit into the second hole of the light-emitting element drive circuit board.

With this arrangement, mechanical connection and electrical connection of the light-emitting element drive circuit board are obtained at the same time. Thus, an optical transmitter-receiver module easy to assemble is realized.

In one embodiment, the optical transmitter-receiver module a first hole provided in the light-receiving element processing circuit board at one of opposite end portions thereof, a projection provided at the jack section, a second hole provided in the light-receiving element processing circuit board at the other of the opposite end portions thereof, and positioning the light-receiving element processing circuit board by press-fitting the projection of the jack section into the first hole of the light-receiving element processing circuit board and connectively inserting a terminal of the light emitting/receiving unit into the second hole of the light-receiving element processing circuit board.

With this arrangement, mechanical connection and electrical connection of the light-receiving element processing circuit board are obtained at the same time. Thus, an optical transmitter-receiver module easy to assemble is realized.

In one embodiment, an armor shield plate is mounted outside of the light-emitting element drive circuit board and the light-receiving element processing circuit board.

With this arrangement, influence of external noises is avoided. Thus, an optical transmitter-receiver module having a high signal-to-noise ratio is achievable.

In one embodiment, the optical transmitter-receiver module has an armor shield positioning means having a hole provided at the jack section and grounding portions each provided at the light-emitting element drive circuit board and the light-receiving element processing circuit board, and positioning the armor shield plate by inserting a portion of the armor shield plate in the hole of the jack section, with the armor shield plate connected and fixed to the grounding portions of the light-emitting element drive circuit board and light-receiving element processing circuit board by soldering.

With this arrangement, the mechanical connection of the armor shield and the electrical connection thereof to the grounding potential are obtained at the same time. Thus, an optical transmitter-receiver module easy to assemble is realized.

In one embodiment, a lead frame on which the light-emitting element is mounted and a lead frame on which the light-receiving element is mounted are arranged so that lead portions of the respective lead frames are extended from mutually different sides.

With this arrangement, an interval between lead terminals (the lead portions of the associated lead frame) of the light-emitting device and lead terminals (the lead portions of the associated lead frame) of the light-receiving device can be made large. In the mutually adjoining arrangement of the lead terminals of the light-emitting device and the lead terminals of the light-receiving device, the influence of electromagnetic noises due to electromagnetic induction between the lead terminals of the adjacent light-emitting device and light-receiving device can be considered to be large. In contrast to this, the influence of electromagnetic noises between the transmission side and the reception side can be reduced with the above-mentioned arrangement of the embodiment. Therefore, an optical transmitter-receiver module having a high signal-to-noise ratio and easy to assemble is realized.

The present invention also provides a method for manufacturing the above optical transmitter-receiver module, comprising the steps of:

making a light-emitting device by molding the light-emitting element;

making a light-receiving device by molding the light-receiving element;

making the light emitting/receiving unit by positioning and fixing the light-emitting device and the light-receiving device and thereafter positioning and fixing optical elements to be associated with the light-emitting device and the light-receiving device, respectively;

making the light-tight partition plate unit by resin-molding, said partition plate unit having a light-tight partition plate; and

assembling the light emitting/receiving unit, the jack section and the partition plate unit together.

This optical transmitter-receiver module manufacturing method can easily assemble an optical transmitter-receiver module which can perform high-quality optical transmission by the full-duplex communication method.

In one embodiment, the method further has the steps of:

mounting a light-emitting element drive circuit board and a light-receiving element processing circuit board to an assembly resulted from the step of assembling the light emitting/receiving unit, the jack section and the partition plate unit together; and

mounting an armor shield to the assembly mounted with the light-emitting element drive circuit board and the light-receiving element processing circuit board.

In one embodiment, in the step of making the light emitting/receiving unit, shield plates are mounted to the light-emitting device and the light-receiving device, respectively, the light-emitting device and light-receiving device mounted with the respective shield plates are positioned and fixed in place by resin-molding, and then the optical elements are positioned and fixed to the already fixed light-emitting device and light-receiving device, respectively, by resin molding.

With this arrangement, an optical transmitter-receiver module, which can easily be assembled and has a high signal-to-noise ratio, can be provided.

Electronic devices such as an information appliance capable of performing high-quality optical transmission by the full-duplex communication scheme are achieved by using the optical transmitter-receiver module according to the present invention as described above.

By employing the above-mentioned optical transmitter-receiver module, there can be provided electronic equipment such as an information domestic appliance capable of performing optical transmission by a high-quality full-duplex communication system.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not intended to limit the present invention, and wherein:

FIG. **1** is a flowchart showing the manufacturing method of an optical transmitter-receiver module according to one embodiment of this invention;

FIG. **2** is a top view of the above optical transmitter-receiver module;

FIG. **3** is a view of the above optical transmitter-receiver module seen from the direction of a plug insertion hole;

FIG. **4** is a side view of the above optical transmitter-receiver module;

FIG. **5** is a sectional view taken along line V—V of FIG. **4**;

FIG. **6** is an enlarged sectional view showing an optical system in the above optical transmitter-receiver module;

FIG. **7** is a flowchart for explaining the manufacturing process steps for a light-emitting device;

FIG. **8** is a flowchart for explaining the manufacturing process steps for a light-receiving device;

FIG. **9**A is a top view of the above light-emitting device, and FIG. **9**B is a side view of the above light-emitting device;

FIG. **10**A is a top view of the above light-receiving device, and FIG. **10**B is a side view of the above light-receiving device;

FIG. **11** is a flowchart for explaining the manufacturing process steps for a light emitting/receiving unit;

FIG. **12**A is a front view of a light-emitting device on which an upper shield plate and a lower shield plate are mounted, FIG. **12**B is a rear view of the above light-emitting device, and FIG. **12**C is a side view of the light-emitting device of FIG. **12**A as viewed from the right-hand side;

FIG. **13**A is a front view of the upper shield plate, and FIG. **13**B is a side view of the upper shield plate;

FIG. **14**A is a front view of the lower shield plate, and FIG. **14**B is a side view of the lower shield plate;

FIG. **15**A is a front view of a light-receiving device on which an upper shield plate and a lower shield plate are mounted, FIG. **15**B is a rear view of the above light-receiving device, and FIG. **15**C is a side view of the light-receiving device of FIG. **15**A as viewed from the right-hand side;

FIG. **16**A is a front view of the upper shield plate, and FIG. **16**B is a side view of the upper shield plate;

FIG. **17**A is a front view of the lower shield plate, and FIG. **17**B is a side view of the lower shield plate;

FIG. **18**A is a front view of a light emitting/receiving unit integrated by secondary injection resin molding, FIG. **18**B is a sectional view taken along line XVIIIb—XVIIIb of FIG. **18**A, FIG. **18**C is a side view of the above light emitting/receiving unit, and FIG. **18**D is a rear view of the above light emitting/receiving unit;

FIG. **19**A is a front view of a transmission prism lens, FIG. **19**B is a view seen from the upper side of the transmission prism lens of FIG. **19**A, and FIG. **19**C is a side view seen from the right-hand side of the transmission prism lens of FIG. **19**A;

FIG. **20**A is a front view of a reception prism lens, FIG. **20**B is a view seen from the upper side of the reception prism lens of FIG. **20**A, and FIG. **20**C is a side view seen from the right-hand side of the reception prism lens of FIG. **20**A;

FIG. **21**A is a front view of a light emitting/receiving unit in which the above transmission prism lens and the reception prism lens are inserted, FIG. **21**B is a sectional view taken along line XXIb—XXIb of FIG. **21**A, FIG. **21**C is a side view of the light emitting/receiving unit, and FIG. **21**D is a rear view of the light emitting/receiving unit;

FIG. **22**A is a side view of a jack section, FIG. **22**B is a side view of a partition plate unit, FIG. **22**C is a side view of a light emitting/receiving unit, and FIG. **22**D is a view of the jack section of FIG. **22**A seen from the lower side;

FIG. **23** is a sectional view of an optical transmitter-receiver module in a state in which an optical plug is inserted in a plug insertion hole;

FIG. **24** is a flowchart for explaining a method of manufacturing the above partition plate unit;

FIG. **25** is a side view of a partition plate unit;

FIG. **26** is a front view of the above partition plate unit;

FIG. **27** is a side view of the partition plate unit of FIG. **26** seen from the right-hand side;

FIG. **28** is a sectional view taken along line XXVIII—XXVIII of FIG. **26**;

FIG. **29** is a side view of an optical cable;

FIG. **30** is a sectional view showing a state in which the front end of an optical plug is fit in a hole of an engagement portion of the partition plate unit;

FIG. **31** is a sectional view of an optical transmitter-receiver module in which an optical plug is inserted in a jack section;

FIG. **32**A is a plan view of a light-emitting element drive circuit board, and FIG. **32**B is a plan view of a light-receiving element amplification electric circuit board;

FIG. **33** is a block diagram schematically showing an optical transmitter-receiver system in which the optical transmitter-receiver module of this invention is employed;

FIG. **34** is a block diagram schematically showing another optical transmitter-receiver system in which the optical transmitter-receiver module of this invention is employed;

FIG. **35**A is a plan view of a partition plate of the first conventional optical transmitter-receiver module, and FIG. **35**B is a side view showing the positional relationship of the partition plate with respect to an optical plug;

FIG. **36**A is a plan view of the partition plate of the above optical transmitter-receiver module, and FIG. **36**B is a side view showing the positional relationship of the partition plate with respect to the optical plug;

FIG. **37**A is a side view showing an essential part of an optical cable that has an optical plug and constitutes an optical transmitter-receiver system with the above optical transmitter-receiver module, and FIG. **37**B is a rear view of the optical cable that has the optical plug; and

FIG. **38** is a sectional view of the second conventional optical transmitter-receiver module.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The optical transmitter-receiver module and electronic equipment of this invention will be described in detail below on the basis of the embodiments thereof shown in the drawings.

In explaining an embodiment of this invention, the outline of a method of manufacturing the optical transmitter-receiver module of this invention will be first described, and the construction of the optical transmitter-receiver module and the details of the manufacturing method will be subsequently described.

FIG. **1** is a flowchart showing the manufacturing method for the optical transmitter-receiver module of this embodiment. The optical transmitter-receiver module of this embodiment is manufactured according to the flowchart of FIG. **1**.

First, in step **S1**, a light-emitting device is manufactured by encapsulating a light-emitting element by transfer molding.

Next, in step **S2**, a light-receiving device is manufactured by encapsulating a light-receiving element by transfer molding.

Next, in step **S3**, the light-emitting device and the light-receiving device are integrated with each other by being subjected to secondary injection resin molding for positioning and fixation of the devices.

Next, in step **S4**, a light emitting/receiving unit is formed by inserting a transmission prism lens as an optical element and a reception prism lens as an optical element to combine the lenses with the integrated devices by tertiary injection resin molding.

Next, in step **S5**, an assembly **1** is manufactured by combining the light emitting/receiving unit with a partition plate unit.

Next, in step **S6**, an assembly **2** is manufactured by combining the assembly **1** with a jack section having a plug insertion hole and an engagement retaining portion for enabling the attaching and detaching of an optical fiber cable provided with an optical plug for optical signal transmission.

Next, in step **S7**, an assembly **3** is manufactured by combining the assembly **2** with a transmission drive electric circuit board as a light-emitting element drive circuit board and a reception amplification electric circuit board as a light-receiving element processing circuit board.

Further, in step **S8**, an optical transmitter-receiver module is manufactured by combining the assembly **3** with an armor shield.

FIGS. **2** through **4** show the external views of the optical transmitter-receiver module of the embodiment. FIG. **2** is a top view of the optical transmitter-receiver module. FIG. **3** is a view of the optical transmitter-receiver module seen from the direction of the plug insertion hole. FIG. **4** is a side view of the optical transmitter-receiver module. In FIGS. **2** through **4** are shown a light emitting/receiving unit **21**, a jack section **22**, an armor shield **23**, a plug insertion hole **24**, external input/output terminals **25** and rectangular holes **26** for retaining shield plates.

FIG. **6** is an enlarged sectional view showing an optical system in the optical transmitter-receiver module. The optical system arrangement of the optical transmitter-receiver module of this embodiment will be described first. In the embodiment, a light-emitting diode (hereinafter referred to as an LED) **34** is employed as a light-emitting element, and a photodiode (hereinafter referred to as a PD) **37** is employed as a light-receiving element.

As shown in FIG. **6**, a partition plate **31** is arranged in front of an optical plug **30** that includes an optical fiber **44**. A prism lens, which is an optical element, is divided into two parts of a transmission prism lens **32** and a reception prism lens **35**, and the partition plate **31** is arranged in the boundary therebetween. This partition plate **31** has a thickness of 50 μm, and an interval between the transmission prism lens **32** and the reception prism lens **35** between which the partition plate **31** is inserted is set to 100 μm. The partition plate **31** is arranged in a center position (in a plane that includes the optical axis of the optical fiber) of the optical plug **30**. The above arrangement is to set the projection area of the front end of the optical plug **30** at 50% on the transmission side and 50% on the reception side.

According to this embodiment, the LED **34** is encapsulated with a molding resin **33** by the transfer molding method or the like, and a transmission lens **39** is provided by the molding resin used at this time. Likewise, the PD **37** is encapsulated with a molding resin **36** by the transfer molding method or the like, and a reception lens **41** is provided by the molding resin used at this time. Transmission light from the LED **34** is collimated by a condenser lens **38** on the transmission prism lens **32** via the transmission lens **39**, refracted by a prism portion **42** and thereafter coupled to an optical fiber **44**. On the other hand, due to the partition plate

31, half the reception light emitted from the optical fiber **44** is refracted by the prism portion **43** of the reception prism lens **35**, thereafter condensed by a condenser lens **40** and coupled with the reception PD **37** via the reception lens **41** of the molding resin **36**. As described above, by inserting the partition plate **31**, the transmission prism lens **32** and the reception prism lens **35** between the LED **34** and PD **37** and the optical fiber **44**, it is enabled to perform transmission and reception, i.e., full-duplex communications by means of one optical fiber **44**.

In this embodiment, the LED **34** is arranged in a position farther than the PD **37** with respect to the front ends of the optical plug **30** and the optical fiber **44**. In this case, a difference between a distance from the optical plug **30** to the light-emitting surface of the LED **34** and a distance from the optical plug **30** to the light-receiving surface of the PD **37** is 1.3 mm. Further, the condenser lens **38** of the transmission prism **32** is arranged in a position farther than the condenser lens **40** of the reception prism lens **35** with respect to the front end of the optical plug **30**. A difference between a distance from the front end of the optical fiber **44** to the condenser lens **38** and a distance from the front end of the optical fiber **44** to the condenser lens **40** is 1 mm. In this embodiment, the partition plate **31** is inserted between the light-emitting device in which the LED **34** is molded by transfer molding and the light-receiving device in which the PD **37** is molded by transfer molding. Therefore, it is impossible to arrange both the LED **34** and the PD **37** at a distance of less than 50 μm from the center position of the optical plug **30**.

With regard to the optical system arrangement on the transmission side, the radiation light intensity of the LED **34** decreases with a peak at the center of the light-emitting portion as the angle increases, and the transmission efficiency becomes higher when the coupling of the light with the optical fiber of the optical plug **30** is attained with less bending of the ray of light at the prism portion **42** of the transmission prism lens **32**. Therefore, the efficiency increases as the angle made between the light-emitting direction of the LED **34** and the direction of the optical axis of the optical fiber of the optical plug **30** decreases. For the above reasons, it may be conceivable to adopt a method of decreasing the angle between the LED **34** and the optical plug **30** by putting the LED **34** away from the front end of the optical plug **30**. However, for the sake of downsizing the optical transmitter-receiver module, to place the LED **34** and the PD **37** away from the optical plug **30** becomes a negative factor due to the increase in size of the optical system. For the above reasons, in this embodiment, the LED **34** is arranged so that the distance from the front end of the optical plug **30** to the light-emitting portion of the LED **34** is about 4.75 mm. In this case, it is difficult to make the light emitted from the LED **34** wholly become parallel light by the transmission lens **39**. Therefore, it is desirable to reduce the interval between the transmission lens **39** integrally molded by transfer molding and the condenser lens **38** of the transmission prism lens **32**, thereby making fast incidence of light on the condenser lens **38**. In this embodiment, the interval between the transmission lens **39** and the condenser lens **38** is set at 50 μm.

On the other hand, with regard to the optical system arrangement on the reception side, because the front end of the optical fiber of the optical plug **30** has a spherical surface, and therefore, the light emitted from the front end of the optical fiber tends to be concentrated toward the center, the reception efficiency is increased by arranging the prism portion **43** of the reception prism lens **35** in a position near the front end of the optical fiber so that the light is bent toward the reception side by the prism portion **43** of the reception prism lens **35** before the light strikes the partition plate **31**, and then collimated by means of the condenser lens **40** of the reception prism lens **35** for the coupling with the PD **37** through the reception lens **41**.

For the above reasons, the LED **34** is arranged in the position farther than the PD **37** with respect to the front end of the optical plug **30**. Furthermore, the condenser lens **38** of the transmission prism **32** is also arranged in the position farther than the condenser lens **40** of the reception prism lens **35** with respect to the front end of the optical plug.

As described above, the optical positions of the LED **34** and the PD **37** are optimized. According to the optical simulation results of the optical system arrangement of this embodiment, the transmission efficiency of this optical system was 21.3%, and the reception efficiency was 31.2%, meaning that high transmission efficiency and reception efficiency were obtained.

The process steps of manufacturing the optical transmitter-receiver module of this embodiment will be described below.

FIG. **7** is a flowchart for explaining the process steps of manufacturing a light-emitting device. FIG. **9**A shows a top view of the light-emitting device. FIG. **9**B shows a side view of the light-emitting device. As the light-emitting device of this embodiment, an LED (light-emitting diode) **51** (shown in FIG. **9**A) is employed.

First, in step S**11**, the LED **51** of the light-emitting element is die-bonded onto a lead frame **50** (shown in FIG. **9**A) with silver paste, conductive resin, indium or the like. The lead frame **50** is formed by cutting or etching a metal plate, such as a copper plate or an iron plate, plated with silver. One electrical connection of the LED **51** is provided in a prescribed position on the lead frame **50** using the silver paste, conductive resin, indium or the like, whereby the LED is fixed.

Next, in step S**12**, the other electrical connection of the LED **51** is provided in a prescribed position on the lead frame **50** by wire bonding with a gold wire or an aluminum wire **54** (shown in FIG. **9**A).

Subsequently, in step **13**, the resulting assembly is set in a metal mold and encapsulated with a molding resin **53** (shown in FIGS. **9**A and **9**B) by transfer molding.

As the resin used in the process steps of manufacturing this light-emitting device, an epoxy-based transparent material is used. At this time, by integrally forming a lens portion **52** (shown in FIGS. **9**A and **9**B) that has a spherical or aspherical surface, using the molding resin, in a direction inclined with respect to the light-emitting element, the efficiency of coupling of the light-emitting element with the optical fiber during transmission can be improved.

FIG. **8** is a flowchart for explaining the process steps of manufacturing a light-receiving device. FIG. **10**A is a top view of the light-receiving device. FIG. **10**B is a side view of the light-receiving device. As the light-receiving device of this embodiment, a PD (photodiode) **71** (shown in FIG. **10**A) is employed.

First, in step S**21**, the PD **71** and a first-stage amplification IC (hereinafter referred to as a preamplifier) **75** (shown in FIG. **10**A) are die-bonded onto a lead frame **70** (shown in FIG. **10**A) using silver paste, conductive resin, indium or the like, similarly to the manufacturing flow of the light-emitting device. The lead frame **70** is formed by cutting or etching a metal plate, such as a copper plate or an iron plate, plated with silver. The electrical connection of the PD **71** at its bottom side and the grounding connection of the preamplifier are provided in a prescribed position on the lead frame using the silver paste, conductive resin, indium or the like, whereby the PD and the preamplifier are fixed.

Next, in step S**22**, the light-receiving surface side of the PD **71** and the preamplifier **75** are connected to prescribed positions on the lead frame **70** by wire bonding using a gold wire or an aluminum wire **74** (shown in FIG. **10**A). In this case, the light-receiving surface side electrode of the PD and the PD connection pad of the preamplifier are electrically connected directly to each other by wire bonding using a wire **76** in order to prevent the capacitance from increasing.

Subsequently, in step S**23**, the resulting assembly is set in a metal mold and encapsulated with a molding resin **73** (shown in FIGS. **10**A and **10**B) by transfer molding.

As the resin used in the process of manufacturing this light-receiving device, an epoxy-based transparent material is used. At this time, by integrally forming a lens portion **72** (shown in FIGS. **10**A and **10**B) that has a spherical or aspherical surface, using the molding resin, in a direction inclined with respect to the light-receiving element, the efficiency of coupling of the light-receiving element with the optical fiber during reception can be improved. Although the PD and the preamplifier are constructed of individual chips in this embodiment, it is acceptable to use a single-chip construction of a photoelectric IC (OPIC, OEIC) or the like.

FIG. **11** is a flowchart for explaining the process steps of manufacturing a light emitting/receiving unit. First, a shield plate is mounted on the light-emitting device in step S**31**, and a shield plate is mounted on the light-receiving device in step S**32**.

Next, in step S**33**, the light-emitting device and the light-receiving device, on each of which the shield plate has been mounted, are integrated with each other into a unit by secondary injection resin molding.

Next, in step S**34**, prism lenses are inserted in the unit obtained by the secondary injection resin molding.

Next, in step S**35**, tertiary injection resin molding is performed to form a lens fixing portion **195**, which will be described later, to fix the lens.

The steps of mounting the shield plate on the light-emitting device will be described in more detail next.

FIG. **12**A through FIG. **12**C are views of an assembly in which an upper shield plate **93** and a lower shield plate **94** are mounted on the light-emitting device **91** so as to cover the device. FIG. **12**A is a front view of the assembly seen from the direction of the lens portion **92** integrally molded with a molding resin. FIG. **12**B is a view of the assembly seen from the opposite side from the lens portion **92**. FIG. **12**C is a side view of the assembly seen from the right-hand side of FIG. **12**A. FIG. **13**A is a front view of the upper shield plate **93**. FIG. **13**B is a side view of the upper shield plate **93**. FIG. **14**A is a front view of the lower shield plate **94**. FIG. **14**B is a side view of the lower shield plate **94**.

In order to restrain the influence of electromagnetic noises, which are generated from the LED and incident on the adjacent light-receiving device and the amplification circuit for the light-receiving device, the light-emitting device **91** shown in FIGS. **12**A through **12**C is shielded with a structure in which the device is covered with a metal plate of iron, copper or the like as a means for removing electromagnetic noises radiated to the outside from the light-emitting device, wires and lead terminals when the light-emitting element is subjected to high-speed switching.

In order to easily perform the assembling, this shield plate provided by the metal plate of iron, copper or the like is divided into two parts of the upper shield plate **93** and the lower shield plate **94**. The upper shield plate **93** has a structure for covering the upper portions other than the lens portion **92** and is provided with a hole **100** (shown in FIG. **13**A) for avoiding the lens portion **92**. The upper shield plate **93** is electrically connected to the ground by means of connection terminals **95**, and the lower shield plate **94** is electrically connected to the ground by means of connection terminals **96**, restraining the entry of electromagnetic noises. The connection terminals **95** and **96** of the upper shield plate **93** and the lower shield plate **94** are extended in a direction in which the lead terminals **99** of the light-emitting device **91** are extended for the provision of a structure capable of providing continuity to the grounding terminals included in the lead terminals **99**. Thus, the connection terminals **95** and **96** are electrically connected to the ground for the restraint of the entry of electromagnetic noises. The electrical connection of the connection terminals **95** and **96** of the upper shield plate **93** and the lower shield plate **94** with the grounding terminals (located on both sides in FIG. **12**A) in the lead terminals **99** of the light-emitting device **91** are provided by welding (or soldering) at connecting portions **101**, and the upper shield plate **93** and the lower shield plate **94** are positioned and fixed.

As measures for positioning and fixing the upper shield plate **93** and the lower shield plate **94**, a structure for preventing the upper shield plate **93** from being displaced in the upward, downward, rightward and leftward directions as shown in FIG. **12**A is provided by making the hole **100** of the upper shield plate **93** for avoiding the lens portion **92** of the light-emitting device **91** have a hole diameter slightly greater than the diameter of the lens portion **92**. In this embodiment, the hole **100** has a diameter of the lens portion diameter plus 0.1 mm. Further, by providing the connection terminals **95** and **96** of the upper shield plate **93** and the lower shield plate **94** with sectionally U-shaped portions **97** and **98** as the positioning and fixing means, reliable positioning and fixation are achieved by sideways holding the grounding terminals (located on both sides in FIGS. **12**A and **12**B) of the lead terminals **99** of the light-emitting device **91**. Moreover, the upper shield plate **93** and the lower shield plate **94** not only restrain the radiation of electromagnetic noises but also restrain the unnecessary light emission from the device portions other than the lens portion **92**.

The process of mounting the shield plate on the light-receiving device will be described next.

FIG. **15**A through FIG. **15**C are views of an assembly in which an upper shield plate **113** and a lower shield plate **114** are mounted on a light-receiving device **111** so as to cover the device. FIG. **15**A is a front view of the assembly seen from the direction of a lens portion **112** integrally formed by a molding resin. FIG. **15**B is a view of the assembly seen from the opposite side from the lens portion. FIG. **15**C is a side view of the assembly seen from the right-hand side of FIG. **15**A. FIG. **16**A is a front view of the upper shield plate **113**. FIG. **16**B is a side view of the upper shield plate **113**. FIG. **17**A is a front view of the lower shield plate **114**. FIG. **17**B is a side view of the lower shield plate **114**.

In order to restrain the influence of electromagnetic noises from the outside, such as external noises from the adjacent light-emitting device and the electric circuit for driving the light-emitting device, the light-receiving device **111** shown in FIGS. **15**A through **15**C is shielded with a structure in which the device is covered with a metal plate of iron, copper or the like as a noise removing means.

In order to easily perform the assembling, this shield plate provided by the metal plate of iron, copper or the like is divided into two parts of the upper shield plate **113** and the lower shield plate **114**. The upper shield plate **113** has a structure for covering the device upper portions other than the lens portion **112** and is provided with a hole **120** (shown in FIG. **16**A) for avoiding the lens portion **112**. The upper shield plate **113** is electrically connected to the ground by means of a connection terminal **115**, and the lower shield plate **114** is electrically connected to the ground by means of a connection terminal **116**, restraining the entry of electromagnetic noises. The connection terminals **115** and **116** of the upper shield plate **113** and the lower shield plate **114** are extended in a direction in which the lead terminals **119** of the light-receiving device **111** are extended for the provision of a structure capable of providing continuity to a grounding terminal (the second one from the right-hand side in FIG. **15**A) included in the lead terminals **119**. Thus, the connection terminals **115** and **116** are electrically connected to the ground for the restraint of the entry of electromagnetic noises. The electrical connection of the connection terminals **115** and **116** of the upper shield plate **113** and the lower shield plate **114** with the grounding terminal (the second one from the right-hand side in FIG. **15**A) in the lead terminals **119** of the light-receiving device **111** are provided by welding (or soldering) at a connecting portion **121**, and the upper shield plate **113** and the lower shield plate **114** are positioned and fixed.

As means of positioning and fixing the upper shield plate **113** and the lower shield plate **114**, a structure for preventing the upper shield plate **113** from being displaced in the upward, downward, rightward and leftward directions as shown in FIG. **15**A is provided by making the hole **120** of the upper shield plate **113** for avoiding the lens portion **112** of the light-receiving device **111** have a hole diameter slightly greater than the diameter of the lens portion **112**. In this embodiment, the hole **120** has a diameter of the diameter of the lens portion **112** plus 0.1 mm. Further, by providing the connection terminals **115** and **116** of the upper shield plate **113** and the lower shield plate **114** with sectionally U-shaped portions **117** and **118** as the positioning and fixing means, reliable positioning and fixation are achieved by sideways holding the grounding terminal in the lead terminals **119** of the light-receiving device. Moreover, the upper shield plate **113** and the lower shield plate **114** not only restrain the radiation of electromagnetic noises but also restrain the incidence of unnecessary light from the device portions other than the lens portion **112**.

The process of integrating the light-emitting device and the light-receiving device, on which the shield plates are mounted, by secondary injection resin molding will be described next.

FIG. **18**A is a front view of the light emitting/receiving unit integrated by the secondary injection resin molding. FIG. **18**B is a sectional view taken along line XVIIIb—XVIIIb of FIG. **18**A. FIG. **18**C is a side view of the light emitting/receiving unit. FIG. **18**D is a rear view of the light emitting/receiving unit.

As shown in FIGS. **18**A through **18**D, the light-emitting device **131** with the welded shield plates **138** and **139** and the light-receiving device **132** with the welded shield plates **140** and **141** are positioned and fixed, with the lead frame of the light-emitting device **131** and the lead frame of the light-receiving device **132** arranged so as to extend to the mutually opposite sides. By arranging the light-emitting device **131** and the light-receiving device **132** such that their sides opposite from the lead terminals **133**, **134** confront each other, an interval or spacing between the lead terminals **133** of the light-emitting device **131** and the lead terminals **134** of the light-receiving device **132** can be made large, so that the influence of the electromagnetic noises from the light-emitting device **131** on the light-receiving device **132** can be restrained. Moreover, for the reason that the influence of electromagnetic noises due to electromagnetic induction between the lead terminals of the light-emitting device and the lead terminals of the light-receiving device is considered to be large in the adjacent arrangement, the influence of electromagnetic noises can be made smaller with the aforementioned spaced arrangement.

The positioning and fixing means of the light-emitting device **131** and the light-receiving device **132** are provided by the secondary injection resin molding on the basis of positioning pin holes **136** and **137** of the lead frames of the light-emitting device **131** and the light-receiving device **132** with an injection molding resin **135**. In this secondary injection resin molding stage, boss pin holes **142** and **143** (shown in FIG. **18**A) to be used as a positioning means for the prism lenses that serve as an optical element for transmission and an optical element for reception, described later, are formed at the same time.

The process of inserting the prism lenses into the light emitting/receiving unit integrated by the secondary injection resin molding will be described next.

The prism lenses to be inserted will be described first. FIG. **19**A is a front view of a transmission prism lens. FIG. **19**B is a side view seen from the upper side of the transmission prism lens of FIG. **19**A. FIG. **19**C is a side view seen from the right-hand side of the transmission prism lens of FIG. **19**A.

In this embodiment, the transmission prism lens **161** shown in FIGS. **19**A through **19**C is employed as an optical element for transmission. The transmission prism lens **161** has a structure in which a prism portion **162** and a condenser lens portion **163** are combined into one piece. The transmission prism lens **161** is formed by the injection molding method or the like, and it is desirable to select a material having excellent weather resistance for the prism lens. For example, acrylic, PMMA (polymethyl methacrylate) or the like can be employed. The transmission prism lens **161** is provided with boss pins **164** that are integrally formed in the injection molding stage as a positioning means for the second injection mold in a portion that has no relation to the optics. Moreover, by providing a satin finish to the surfaces **165** and **166** of the transmission prism lens **161**, which do not contribute to the optics, so that the unnecessary light emission and reflection of the emission light from the optical fiber are restrained.

FIG. **20**A is a front view of the reception prism lens. FIG. **20**B is a side view seen from the upper side of the reception prism lens of FIG. **20**A. FIG. **20**C is a side view seen from the right-hand side of the reception prism lens of FIG. **20**A.

In this embodiment, the reception prism lens **171** shown in FIGS. **20**A through **20**C is employed as an optical element for reception. The reception prism lens **171** has a structure in which a prism portion **172** and a condenser lens portion **173** are integrated with each other. The reception prism lens **171** is also formed by the injection molding method or the like similarly to the transmission prism lens **161**, and it is desirable to select a material of excellent weather resistance for the prism lens. For example, acrylic, PMMA or the like is employable. The reception prism lens **171** is provided with boss pins **174** that are integrally formed in the injection molding stage as a positioning means for the second injection mold in a portion that has no relation to the optics. Moreover, by providing a satin finish to the surfaces **175** and **176** of the reception prism lens **171**, which do not make any optical contribution so that the unnecessary light emission and reflection of the emission light from the optical fiber are restrained.

FIG. **21**A is a front view of a light emitting/receiving unit in which a transmission prism lens **182** and a reception prism lens **183** are inserted. FIG. **21**B is a sectional view taken along line XXIb—XXIb of FIG. **21**A. FIG. **21**C is a side view of the light emitting/receiving unit. FIG. **21**D is a rear view of the light emitting/receiving unit.

As shown in FIGS. **21**A through **21**D, the transmission prism lens **182** and the reception prism lens **183** are fixed in positions by inserting the boss pins **184** and **185** as a positioning means into the boss pin holes **142** and **143** (shown in FIG. **18**A) formed in the secondary injection molding process for integrating or uniting the light-receiving and -emitting devices.

It is possible that the transmission prism lens **161** and/or the reception prism lens **171** falls off the assembly during the subsequent manufacturing process steps if they are simply inserted in the secondary injection molded product. Therefore, lens fixing portions **195** are formed by tertiary injection resin molding to fix the lenses.

Further, in the lens fixing portion **195**, pins **186** and **187** employed as a positioning means with respect to a jack section **202** (shown in FIG. **22**A) described later are provided in two places by integral molding. The pins **186** and **187** have different pin diameters in order to prevent the insertion thereof in the wrong directions with regard to the transmission side and the reception side when positioned and fixed with respect to the jack section **202**. Moreover, since mere press-fitting involves a risk of detachment of the jack section **202** from the light emitting/receiving unit, the jack section **202** is provided with hooks **205** (shown in FIG. **22**A), and the light emitting/receiving unit **201** that has undergone the tertiary injection resin molding is provided with groove portions **194** to receive the hooks **205**. The hooks **205** of the jack section **202** and the groove portions **194** of the light emitting/receiving unit **201** constitute an anti-detachment means. In the tertiary injection resin molding stage, by carrying out the tertiary injection resin molding by performing positioning on the basis of the pin holes **188** and **189** of the lead frames together with the light-emitting device **190** and the light-receiving device **191** as in the secondary injection resin molding stage, it is possible to improve the positioning accuracy of the positioning pins **186** and **187** with respect to the light-emitting device **190**, light-receiving device **191** and lenses **192** and **193**, which are integrally molded by transfer molding, the prism lenses **182** and **183** for transmission and reception, and the jack section **202**.

FIG. **22**A is a side view of the jack section **202**. FIG. **22**B is a side view of a partition plate unit **221**. FIG. **22**C is a side view of a light emitting/receiving unit **201**. FIG. **22**D is a view of the jack section **202** of FIG. **22**A as viewed from the lower side.

As shown in FIGS. **22**A through **22**D, the jack section **202**, the partition plate unit **221** and the light emitting/receiving unit **201** are assembled together through positioning by inserting the pins **186** and **187** of the light emitting/receiving unit **201** formed by the tertiary injection resin molding into pin holes **208** provided in the jack section **202**. The jack section **202** has a plug insertion hole (indicated by **24** in FIG. **3**) and an engagement retaining portion for enabling the attaching and detaching of an optical fiber cable (not shown) to which an optical plug is attached. This engagement retaining portion is designed to detachably retain the optical plug inserted in the plug insertion hole in the prescribed position of the jack section **202** by holding the optical plug by a constricted portion (**242** in FIG. **29**) by means of a leaf spring or the like (**209** in FIG. **22**). Moreover, as described above, since mere press-fitting involves a risk of detachment of the light emitting/receiving unit from the jack section **202**, the jack section **202** is provided with hooks **205**, **205**, and the light emitting/receiving unit **201** that has undergone the tertiary injection resin molding is provided with groove portions **194** on both sides to receive the hooks **205**, **205** to thereby prevent the detachment of the jack in the pulling direction. The partition plate unit **221** for separating the optical path of the transmission signal light from the optical path of the reception signal light is held between the jack section **202** and the light emitting/receiving unit **201**. The partition plate unit **221** is constructed so as to be movable in the lengthwise direction of the optical fiber by virtue of a partition plate unit retaining portion **215** provided at the jack section **202** and a spring **212** as a spring means.

FIG. **24** shows a flowchart for explaining the manufacturing method for the partition plate unit. This partition plate unit is manufactured by integrating the partition plate **211** with resin molded piece **213** for guiding the optical plug by insert molding in step **S41** and then press-fitting the spring **212**. The spring **212** may be integrated with the resin molded piece **213** by insert molding.

FIG. **23** shows a sectional view of an optical transmitter-receiver module in a state in which an optical plug **240** is inserted in a plug insertion hole **227**. As shown in FIG. **23**, the partition plate unit **221** is provided with a partition plate **211**, which is positioned between a light-emitting device **222** and a light-receiving device **223** and between a transmission prism lens **224** and a reception prism lens **225**, and an engagement portion **214** to which one end of the partition plate **211** is fixed. A partition plate unit retaining portion **215** for retaining the partition plate unit **221** movably in the direction of the optical axis of the optical fiber is provided on the jack section **202** side of the partition plate unit **221**.

FIG. **25** is a side view of the partition plate unit **221**. FIG. **26** is a front view of the partition plate unit **221**. FIG. **27** is a side view of the partition plate unit **221** of FIG. **26** seen from the right-hand side. FIG. **28** is a sectional view taken along line XXVIII—XXVIII of FIG. **26**.

As is clearly depicted in the sectional view of the partition plate unit **221** shown in FIG. **28**, the engagement portion **214** has a generally truncated cone-shaped hole **216** at the center to smoothly house the front end of the optical plug **240** (shown in FIG. **23**). The engagement portion **214** also has an annular projection **217** that projects inwardly in the radial direction at the bottom of this hole **216**. This annular projection **217** has a thickness smaller than 0.4 mm ($0<x<0.4$ mm). The thickness of the annular projection **217** corresponds to an interval between the front end of the optical plug **240** and a surface **218** (located on the side opposite to the hole **216**) of the partition plate **211**. The partition plate **211** is constructed of a phosphor bronze plate or a stainless steel plate of a thickness of about 50 μm and is fixed to the engagement portion **214** at the bottom portion of the hole **216** by insert molding. The surface **218** (located on the side opposite to the hole **216**) of the partition plate **211** is coated with a photoabsorption material (black paint containing carbon or the like), which forms a photoabsorption layer. Moreover, as is clearly depicted in the enlarged side view of the partition plate unit **221** shown in FIG. **25** and the front view of the partition plate unit **221** shown in FIG. **26**, the leaf spring **212**, which is constructed of a phosphor bronze plate, a stainless steel plate or a beryllium copper, is mounted to the engagement portion **214** in two places (on the upper left side and the lower right side of FIG. **26**) by insert molding or press-fitting. The spring **212** is always brought in contact with the light emitting/receiving unit **201** (shown in FIG. **23**). Therefore, the engagement portion **214** is always urged toward the plug insertion hole **227** (shown in FIG. **23**), i.e., toward the optical fiber by the spring **212**. In FIG. **23**, the engagement portion **214** is slidably fit in a rectangular hole (not shown) provided at the partition plate unit retaining portion **215** of the jack section **202**. Therefore, if a force greater than the force of the spring **212** is exerted on the engagement portion **214**, then the engagement portion **214** and the partition plate **211** fixed to the engagement portion **214** move in the direction opposite from the plug insertion hole **227** (i.e., toward the light-emitting/receiving unit **201**).

The optical transmitter-receiver module of this embodiment constitutes an optical transmitter-receiver system together with the optical cable shown in FIG. **29**. This optical cable has optical plugs **240** at the opposite end portions (only one end portion is shown in FIG. **29**), and an optical fiber is inserted in the optical plugs **240**. As is apparent from FIG. **29**, this optical plug **240** is provided with no anti-rotation mechanism and is therefore rotatable. An optical fiber end surface **241***a* at the front end of the optical plug **240** projects from the plug (ferrule) end, and its outside portion in the radial direction covers part of the plug end surface **240***a* (see FIG. **30**). The optical fiber end surface **241***a* is a curved surface rotationally symmetrical relative to the optical axis of the optical fiber and is a convex surface. A flux of reflection light from the curved surface is expanded and therefore absorbed into the cladding of the fiber when propagating through the fiber. Consequently, the reflection light going out of the fiber becomes reduced in comparison with an optical fiber that has a flat end surface.

FIG. **30** is a sectional view showing a state in which the front end of the optical plug **240** is fit in the hole **216** of the engagement portion **214** of the partition plate unit **221**.

As is clearly depicted in FIG. **30**, when the optical plug **240** is put in the optical transmitter-receiver module through the plug insertion hole **227**, the front end of the optical plug **240** is fit in the hole **216** of the engagement portion **214** of the partition plate unit **221**, and a portion **240***b* that belongs to the plug end surface **240***a* and is not covered with the fiber end surface comes into contact with a surface (engagement surface) **217***a* of the annular projection **217** of the engagement portion **214**. As a result, the relative position of the front end of the optical fiber **241** to the partition plate **211** is determined. At this time, a gap G corresponding to the thickness of the annular projection **217** of the engagement portion **214** is defined between the plug end surface **240***a* (hence the outer edge of the optical fiber end surface **241***a*) and the opposite surface **211***a* of the partition plate **211**. Since the optical fiber end surface **241***a* is made convex, the gap between the optical fiber end surface **241***a* and the opposite surface **211***a* of the partition plate **211** decreases as going towards the center of the fiber. However, due to the presence of the annular projection **217** that is projecting inward in the radial direction, the optical fiber end surface does not touch the opposite surface of the partition plate. The dimension of this gap G, which depends on the structure of the optical system, should preferably have a value smaller than 0.4 mm (0 mm<G<0.4 mm) and be as small as possible. In this embodiment, the gap G is set at about 0.3 mm. It was experimentally confirmed that the bit error rate (BER) could be 10^{-12} when the gap G was about 0.3 mm, and the full-duplex communication system can sufficiently be provided.

As is obvious from the above, the annular projection **217** has a thickness greater than the amount of projection of the convex surface of the optical fiber **241** from the optical plug end surface **240***b*. Moreover, the opposite surface **211***a* (facing the optical fiber end surface **241***a*) of the partition plate **211** has a linear shape such that no gap is defined between an opposite surface **214***a* (located on the side opposite from the surface **217***a* to be engaged with the optical plug **240**) of the plastic-molded engagement portion **214** and the opposite surface **211***a* of the partition plate **211**.

The engagement portion **214** of the partition plate unit **221** is urged toward the plug insertion hole **227** (shown in FIG. **23**), i.e., toward the optical plug **240**, by the spring **212**. Therefore, the engagement surface **217***a* is always pressed against the plug end surface **240***a* with a minute force. Moreover, the optical fiber end surface **241***a* is a curved surface rotationally symmetrical relative to the optical axis of the optical fiber **241**. Therefore, even if the optical plug **240** is rotated, the shape of the optical fiber end surface **241***a* does not change with respect to the opposite surface **211***a* of the partition plate **211**, and the gap G is kept constant.

The optical plug **240** including the optical fiber **241** has a variation in length due to the manufacturing process. Therefore, if the position of the partition plate **211** is fixed by fixing the partition plate unit **221** to the jack section **202** (shown in FIG. **23**) or by another means, then the gap between the optical fiber end surface **241***a* and the opposite surface **211***a* of the partition plate **211** may become greater than is set, depending on the length of the optical plug **240**. If the optical plug **240** is a round type plug according to the EIAJ-RC5720B standard, then the length of the plug may vary between 14.7 and 15 mm due to the variations in the manufacturing process. If the gap is set at 0.2 mm and the position of the partition plate **211** is fixed in conformity to the longest optical plug **240**, then there may occur a gap of 0.5 mm depending on the plug. However, in the optical transmitter-receiver module of this embodiment, the initial position of the partition plate unit **221** (more specifically, of the engagement portion **214**) is set at a position that can cope with the length of the possible shortest optical plug **240**, and the partition plate unit **221** is made movable in the lengthwise direction of the optical fiber **241** with the engagement portion **214** pressed against the plug end surface **240***b* by the minute force of the spring **212**. Therefore, whatever length the optical plug **240** inserted has, the interval of the aforementioned gap can be kept constant.

Moreover, since the plug end surface **240***b* in contact with the engagement surface **217***a* slides on the latter by the rotation of the optical plug **240**, it is desirable to use for the engagement surface **217***a* a material of a small sliding friction coefficient and excellent abrasion resistance, such as fluoroplastic and ultrahigh molecular weight polyethylene.

In the assembly **1** of the structure in which the partition plate unit **221** is held between the light emitting/receiving unit **201** and the jack section **202**, a surface **211***b* of the partition plate **211**, which is located on the side opposite from the opposite surface **211***a* facing the optical fiber **241**, is to be inserted into the partition plate guiding groove portion **228** (shown in FIG. **23**) of the light emitting/receiving unit **201**. As shown in FIG. **23**, since the light-emitting device **222** is located farther apart from the optical fiber end surface in the direction of the optical axis of the optical fiber **241** than the light-receiving device **223** is, the partition plate **211** is made in a length such that the partition plate **211** extends beyond the bottom portion of the lens **222***a* of the light-emitting device **222**. With this arrangement, light from the light-emitting device **222** that is not incident on the transmission prism lens **224**, is prevented from enter the light-receiving device **223** directly or after being reflected on the reception prism lens **225**.

The operation of the optical transmitter-receiver system of this embodiment will be described next.

FIG. **5** shows a sectional view of the essential part of one side of the optical transmitter-receiver system where the optical plugs **240** at both ends of the optical cable are each inserted in the respective optical transmitter-receiver modules. Once a transmission signal (electrical signal) is inputted from the outside of the optical transmitter-receiver module **20** via the input/output terminal **25** (shown in FIG. **4**), an LED **514** that serves as a light-emitting device is driven by a transmission drive electric circuit board **509** on which a transmission drive IC **512** is mounted, so that transmission signal light rays (optical signal) are emitted from the LED **514**. The transmission signal light rays are substantially collimated by a transmission lens **516** formed at the surface of the light-emitting device **501**, and then enter a transmission prism lens **503**, by which the light rays deflect the optical path and enter the optical fiber **241**. At this time, transmission light rays reflected from an end surface, of the optical fiber **241**, near to the optical transmission and reception module (hereinafter referred to as an "optical fiber end surface on the near side") pass through the gap G between the partition plate **211** and the optical fiber end (shown in FIG. **30**) and enter the light-receiving device **502**. At this time, since the gap G has a small dimension of 0.3 mm, the incident light is sufficiently small in light quantity.

The transmission light rays which have been transmitted through the optical fiber are partly reflected by an end surface, of the optical fiber **241**, far from the optical transmission and reception module (hereinafter referred to as an "optical fiber end surface on the far side"). However, since the optical fiber end surface on the far side is a convex surface, a flux of reflection light rays is expanded and absorbed into the cladding while propagating through the optical fiber **241**. As a result, little reflection light goes out of the optical fiber end surface **241***a* on the near side.

On the other hand, the transmission signal light discharged from the optical fiber end surface on the far side is incident on the optical transmitter-receiver module of the other party of communication. Assuming that the optical transmitter-receiver module of the other party of communication has the same construction (for which the same reference numerals will be used in the following description), the transmission signal light first reaches the opposite surface **211***a* (shown in FIG. **30**) of the partition plate **211**. However, since this opposite surface **211***a* is coated with a photoabsorption material (black paint containing carbon or the like), no reflection light is generated here.

Subsequently, the transmission signal light incident on the reception prism lens **504** has its optical path changed and is condensed by a reception lens **517** formed on the surface of the light-receiving device **502** to enter a PD **515** that serves as a light-receiving device.

The incident light is partially reflected on this PD **515**. However, because the incident light was obliquely incident on the PD **515**, the light is reflected in the opposite oblique direction and does not return to the transmission prism lens **504**. Subsequently, the light incident on the PD **515** is photoelectrically converted into an electric signal, amplified by a reception amplification electric circuit board **510** on which an amplification IC **513** is mounted, and taken out as a reception signal through the external input/output terminal **25** (shown in FIG. **4**) to the outside of the optical transmitter-receiver module.

This optical transmitter-receiver system suppresses the electrical crosstalk by using the shield plates and suppresses the optical crosstalk by using the partition plate unit **506** that has the partition plate opposite to the optical fiber end surface with interposition of a small gap. Therefore, optical transmission by the full-duplex communication scheme is achieved. Moreover, because the gap is provided between the partition plate and the optical fiber end surface, no damage due to the rotation of the optical plug **240** occurs on the optical fiber end surface and the partition plate.

The processes of assembling the light-emitting element drive electric circuit board, the light-receiving element amplification electric circuit board and the armor shield will be described next.

FIG. **31** is a sectional view of the optical transmitter-receiver module where the optical plug **240** is inserted in the jack section **202**. In FIG. **31**, lead terminals **251** of the light-emitting device **222** of the light emitting/receiving unit **201** are inserted into connection holes **253** provided at the light-emitting element drive electric circuit board **252**, and electrically connected by soldering. Likewise, lead terminals **254** of the light-receiving device **223** of the light emitting/receiving unit **201** are inserted into connection holes **256** provided at the light-receiving element amplification electric circuit board **255**, and electrically connected by soldering.

FIG. **32**A is a plan view of the light-emitting element drive circuit board **252**. FIG. **32**B is a plan view of the light-receiving element amplification electric circuit board **255**. As shown in FIGS. **32**A and **32**B, the light-emitting element drive circuit board **252**, on which the light-emitting device driver IC **257** is mounted, is generally flat in its height direction. The light-receiving element amplification electric circuit board **255**, on which the reception amplification IC **258** is mounted, is also generally flat in its height direction. The light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** are assembled so that their rear surfaces oppose to each other with the interposition of the assembly **1** (combination of three parts of the light emitting/receiving unit **201**, the partition plate unit **221** and the jack section **202**) therebetween, centering on the optical plug **240**. An assembly **2** is thereby produced. More specifically, the light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** are arranged so that the longer sides of each board are parallel to the axis of the plug **240** and the shorter sides extend along the direction of height of the jack section **202**. As described above, the light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** are each arranged in an upright posture between the light-emitting device **222** (shown in FIG. **31**) and the light-receiving device **223** and the plug insertion hole side of the jack section **202** so that the area of projection becomes minimized, i.e., so that the height direction of the flat light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** corresponds to the widthwise direction of the jack section **202**. With this arrangement, the length of the optical transmitter-receiver module (i.e., the size in the axial direction of the optical plug **240**) and the width of the optical transmitter-receiver module (i.e., the size in the direction perpendicular to the axis of the optical plug **240**) are reduced, by which the downsizing of the optical transmitter-receiver module is achieved. The light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** are provided with boss pin holes **261** and **262** in which the board fixing and positioning boss pins **259** and **260** (shown in FIG. **31**) provided for the jack section **202** are respectively inserted. The positioning and fixation of the light-emitting element drive circuit board **252** is achieved by first inserting the lead terminals **251** (shown in FIG. **31**) of the light-emitting device **222** into the corresponding holes **253** provided at one end of the board and then soldering, and then inserting the board fixing and positioning boss pin **259** (shown in FIG. **31**) of the jack section **202** into the boss pin hole **261** provided at the other end of the board. Furthermore, the positioning and fixation of the light-receiving element amplification electric circuit board **255** is achieved by inserting the lead terminals **254** (shown in FIG. **31**) of the light-receiving device **223** into the holes **256** provided at one end of the board and then soldering, and further inserting the board fixing and positioning boss pin **260** of the jack section **202** into the boss pin hole **262** provided at the other end of the board.

Then, referring to FIG. **31**, an armor shield plate **263** is mounted on an assembly **2** (the light emitting/receiving unit provided with the light-receiving and -emitting boards and the jack) in order neither to receive the influence of external noises nor to let noises go outside. The armor shield plate **263** is fixed by inserting engagement portions of the armor shield plate **263** into the corresponding shield plate retaining rectangular holes **26** (shown in FIG. **3**) provided in four places of the jack section **202** and then soldering the armor shield plate onto a pattern **264** and **265** (shown in FIG. **32**) provided on the light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255** respectively to serve as a grounding portion. By grounding the soldering portions (patterns **264** and **265**) of the light-emitting element drive circuit board **252** and the light-receiving element amplification electric circuit board **255**, the armor shield plate **263** can be grounded, obviating the need for separately providing a grounding terminal to the armor shield plate **263**. Although this embodiment employs the armor shield plate **263** of which the light-emitting side **263***a* and the light-receiving side **263***b* are integrated with each other, it is acceptable to employ an armor shield plate divided into two parts. It is also acceptable to separately provide a grounding terminal for the armor shield plate **263**.

The boss pin hole **261** that serves as a first hole provided at one end of the light-emitting element drive circuit board **252**, the board fixing and positioning boss pin **259** that serves as a projection provided for the jack section **202**, the connection holes **253** that serve as second holes provided at the opposite end of the light-emitting element drive circuit board **252**, and the lead terminals **251** of the light emitting/receiving unit **201**, all together, constitute a board positioning means. Moreover, the boss pin hole **262** that serves as a first hole provided at one end of the light-receiving element amplification electric circuit board **255**, the board fixing and positioning boss pin **260** that serves as a projection provided at the jack section **202**, the connection holes **256** that serve as second holes provided at the opposite end of the light-receiving element amplification electric circuit board **255**, and the lead terminals **254** of the light emitting/receiving unit **201**, all together, constitute a board positioning means.

In the present embodiment, the positioning and fixation are performed by inserting the projections provided at the transmission prism lens and the reception prism lens into the holes provided at the light emitting/receiving unit. However, it is acceptable to perform the positioning and fixation by providing holes at the transmission prism lens and the reception prism lens, providing projections at the optical light emitting/receiving unit and inserting the projections of the optical light emitting/receiving unit into the holes of the prism lenses.

Furthermore, in the present embodiment, the light emitting/receiving unit is prevented from detaching from the jack section by providing hooks at the jack section, providing grooves at the light emitting/receiving unit and fitting the hooks of the jack section in the grooves of the light emitting/receiving unit. However, it is acceptable to prevent the light emitting/receiving unit from the detachment by providing a groove at the jack section, providing a hook at the light emitting/receiving unit and fitting the hook of the light emitting/receiving unit into the groove of the jack section.

The optical transmitter-receiver module of this invention is applicable to electronic equipment such as a digital TV set, a digital BS tuner, a CS tuner, a DVD player, a SuperAudio CD player, an AV amplifier, an audio device, a personal computer, personal computer peripherals, a mobile phone, a PDA (personal data assistant) and the like.

For example, as shown in FIG. **33**, it is possible to serially connect, using a single-core optical fiber cable, a personal computer **601**, a television set **602**, a DVD player **603**, a tuner **604** and a home theater system **605**, these devices employing the optical module of the present invention, to thereby construct an optical transmitter-receiver system for performing bidirectional optical transmission between the devices by the full-duplex communication scheme.

Referring to FIG. **34**, if an audio system **701** and a personal computer **702** are connected with each other via an electric communication interface of IEEE1394 or the like, then noises generated from the personal computer **702** exert bad influence on the audio system **701**. To avoid this, the audio system **701** may be connected with a personal computer **704** via a photoelectric converter **703**. In this case, an optical transmitter-receiver system for performing bidirectional optical transmission by the full-duplex communication scheme using the optical transmitter-receiver module of this invention may be realized by connecting the personal computer **704** with the photoelectric converter **703** via an electric communication interface and connecting the photoelectric converter **703** with the audio system **701** via a single-core optical fiber cable.

Although the LED is employed as a light-emitting element in the embodiment, it is acceptable to employ a semiconductor laser element as the light-emitting element.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. An optical transmitter-receiver module having a light-emitting element for emitting transmission signal light and a light-receiving element for receiving reception signal light, said module being able to perform both transmission of the transmission signal light and reception of the reception signal light by means of a single-core optical fiber, said module comprising:

a jack section for detachably holding an optical plug provided at an end portion of the optical fiber;

a light emitting/receiving unit having the light-emitting element and light-receiving element positioned and fixed in place and molded in one piece; and

a light-tight partition plate unit for separating an optical path of the transmission signal light and an optical path of the reception signal light from each other, said light-tight partition plate being arranged so as to be held between the jack section and the light emitting/receiving unit.

2. The optical transmitter-receiver module as claimed in claim **1**, comprising:

a positioning means having a projection provided at one of the jack section and the light emitting/receiving unit and a hole provided at the other of the jack section and the light emitting/receiving unit, and positioning the light emitting/receiving unit by press-fitting the projection into the hole.

3. The optical transmitter-receiver module as claimed in claim **1**, comprising:

an anti-detachment means having a hook provided at one of the jack section and the light emitting/receiving unit and a groove provided at the other of the jack section and the light emitting/receiving unit to prevent detachment of the light emitting/receiving unit by fitting the hook in the groove.

4. The optical transmitter-receiver module as claimed in claim **1**, comprising:

a light-emitting element drive circuit board for driving the light-emitting element; and

a light-receiving element processing circuit board for processing the reception signal of the light-receiving element,

the light-emitting element drive circuit board and the light-receiving element processing circuit board being arranged with the jack section and the light emitting/receiving unit interposed therebetween.

5. The optical transmitter-receiver module as claimed in claim **4**, comprising:

a board positioning means having a first hole provided in the light-emitting element drive circuit board at one of opposite end portions thereof, a projection provided at the jack section, and a second hole provided in the light-emitting element drive circuit board at the other of the opposite end portions thereof, and positioning the light-emitting element drive circuit board by press-fitting the projection of the jack section into the first hole of the light-emitting element drive circuit board and connectively inserting a terminal of the light emitting/receiving unit into the second hole of the light-emitting element drive circuit board.

6. The optical transmitter-receiver module as claimed in claim **4**, comprising:

a first hole provided in the light-receiving element processing circuit board at one of opposite end portions thereof, a projection provided at the jack section, a second hole provided in the light-receiving element processing circuit board at the other of the opposite end portions thereof, and positioning the light-receiving element processing circuit board by press-fitting the projection of the jack section into the first hole of the light-receiving element processing circuit board and connectively inserting a terminal of the light emitting/receiving unit into the second hole of the light-receiving element processing circuit board.

7. The optical transmitter-receiver module as claimed in claim **4**, comprising:

an armor shield plate mounted outside of the light-emitting element drive circuit board and the light-receiving element processing circuit board.

8. The optical transmitter-receiver module as claimed in claim **7**, comprising:

an armor shield positioning means having a hole provided at the jack section and grounding portions each provided at the light-emitting element drive circuit board and the light-receiving element processing circuit board, and positioning the armor shield plate by inserting a portion of the armor shield plate in the hole of the jack section, with the armor shield plate connected and fixed to the grounding portions of the light-emitting element drive circuit board and light-receiving element processing circuit board by soldering.

9. The optical transmitter-receiver module as claimed in claim **1**, wherein

a lead frame on which the light-emitting element is mounted and a lead frame on which the light-receiving element is mounted are arranged so that lead portions of the respective lead frames are extended from mutually different sides.

10. An electronic device employing the optical transmitter-receiver module as claimed in claim **1**.

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